Middle Articles

HOSPITAL TOPICS

One Year's Experience in a Ministry of Health Dialysis Centre

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Summary: A 10-bed dialysis unit, opened at the London Hospital in 1968, admitted 37 patients during its first year of operation. The aims of the unit were to prepare patients for renal transplantation and to provide instruction for dialysis treatment at home. A total of 2,012 days were spent in hospital, the average intervals between admission, the first dialysis, and discharge being 23.8 and 20 days, respectively. The overall number of readmissions was 1.5 per patient. These figures, together with the increasing number of patients accepted for such treatment, indicate the considerable number of supporting hospital beds, as well as medical and technical staff, required to maintain a dialysis unit.

Introduction

In 1966 the Ministry of Health agreed to finance the establishment in this country of a limited number of centres for regular dialysis treatment. The dialysis unit at the London Hospital was the first such centre to be opened as a result of this decision. This study outlines the problems which exist and the lessons which have been learnt.

The Unit

Permission to build the unit was granted in March 1967. Planning, building, and commissioning took 11 months and cost nearly £50,000. This figure includes architects' fees but excludes the cost of movable equipment, a further £20,000.

The 10-bed unit was originally planned, at the request of the Ministry, with a central supply system in which pre-mixed dialysate was stored in tanks and supplied to monitors at each bedside. During the year it became clear that hospital dialysis alone was impracticable if more than a few patients were to be treated and that home dialysis or renal transplantation were the natural successors to a period of hospital treatment. The central supply system was therefore gradually replaced by a series of individual units suitable for home dialysis, and patients were subsequently accepted only on the understanding that they would ultimately undergo renal transplantation or be maintained on home dialysis.

Organization

As soon as possible after starting treatment in hospital patients were encouraged to take increasing responsibility for

their own treatment in preparation for home dialysis. During this period of training they lived at home and attended the hospital twice weekly for dialysis. They were rehabilitated as fully as possible and encouraged to return to work. Meanwhile a home dialysis administrator arranged structural modifications in the home, and rehousing when necessary.

The average time taken to adapt a home for dialysis, from the time the local council was notified until the modifications were completed, was 22 (range 12 to 33) weeks. The greatest source of delay was the time taken by local government committees to approve the expenditure necessary for modifications to the home. These modifications have now become standard, and once expenditure had been approved conversion times were reduced. This has contributed to the reduction in the average time for home modifications from 25 weeks for the first six patients to 16 weeks for the last three. The average cost of the modifications was about £330 per patient, compared with the figure of £180 suggested originally by the Ministry of Health. In London, with high labour costs, £180 proved an unrealistic figure chiefly owing to the cost of plumbing and decoration and the provision of storage space, which were up to 50% more expensive than anticipated.

As soon as modifications to the house were complete and equipment was installed, each patient spent two to three weeks in the hospital unit undergoing an intensive course of instruction. A booklet compiled by members of the unit, containing comprehensive instruction and advice covering every aspect of his treatment, was given to the patient. During the final week of training the patient's spouse also attended for instruction.

Patients accepted for renal transplantation were dialysed twice weekly in the unit, usually for several months, until they were well enough to withstand nephrectomy. When dialysis proved necessary in the period immediately following transplantation, this was carried out, not in the unit, but in the side-room of a general ward to minimize the risk of cross-infection.

Staff

By February 1969, the dialysis unit staff comprised:

Medical staff: one consultant, three registrars, and one senior house officer.

Nursing staff: three nursing sisters, five staff nurses, three state-enrolled nurses, and two nursing auxiliaries.

Technical staff: two senior technicians and three junior technicians.

Ancillary staff: one home dialysis administrator, one ward-clerk-secretary, one social worker, and one dietitian.

Most of the personnel had other duties outside the unit, and the work of the medical staff was not confined solely to the operation of the unit itself. Other responsibilities included the management of patients with acute renal failure, the assess-

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ment and care of patients undergoing renal transplantation, and the management of other nephrological problems.

The consultant physician, a member of the hospital department of nephrology, held overall responsibility and regularly attended weekly policy meetings and rounds of the group. The responsibilities of the technicians included not only the maintenance of equipment in the unit but also the installation and maintenance of equipment in the home. A senior dietitian and a medical social worker were also attached to the unit but had other responsibilities within the hospital. The ward-clerk-secretary and the home dialysis administrator were fully employed by the unit and both were regarded as indispensable.

One of the most serious problems in the long-term staffing of a dialysis unit is the natural reluctance of medical personnel to be engaged full time in this work, with its inevitably restricted career prospects. In this unit the problem has so far been resolved by a system of rotational service which includes the lecturers on the medical unit and registrars on general firms, thereby combining training in nephrology with continuation of training in general medicine and providing opportunities for research.

Survival

Between 12 February 1968 and 12 February 1969 37 patients were accepted for regular dialysis treatment. During this year four patients died and six others received cadaveric renal transplants, of which five were successful; the sixth resumed regular dialysis treatment after transplant failure. Nine patients were transferred to home dialysis. There was no mortality in either of these groups. The duration of regular dialysis treatment in each patient is shown in Fig. 1.

Hospital Admissions

Admissions to hospital have been analysed to show the degree of rehabilitation achieved and to emphasize the need for an adequate number of hospital beds for patients admitted for initial investigation and assessment before dialysis treatment, or subsequently for readmission when complications arise.

Three periods have been considered.

(1) *First Admission Until First Dialysis.*—The average time spent in hospital before starting regular dialysis treatment was 23.8 (range 1-78 days. During this time patients referred with terminal uraemia were investigated and in some cases resuscitated by peritoneal dialysis.

(2) *First Dialysis until Discharge.*—The average time spent between the first dialysis and discharge home from hospital was 20 (range 2-81) days.

(3) *Readmissions for Complications.*—The average duration of each subsequent readmission for complications associated with regular dialysis treatment, however, was only nine (range 2-46) days. The overall number of readmissions was 1.5 per patient (range 0-6).

Though the average time spent by each patient in hospital once regular dialysis treatment had been started was 32.5 (range 5-96) days—that is, 18.7% of their time—these figures are high for two reasons: (1) the four patients who died spent an average of 63.5% of their time in hospital, and (2) the six

patients who underwent renal transplantation also spent a high proportion of their time (average 54.7%) in hospital, during which time investigation, nephrectomy, and sometimes gastric surgery were performed. Once a patient had been established

FIG. 1.—Duration of regular dialysis treatment of each patient accepted between 12 February 1968 and 12 February 1969. Three patients (Cases 35-37) started regular dialysis treatment in a pilot scheme before the dialysis unit opened. The figure at the end of each bar indicates the number of weeks of treatment.

on regular dialysis treatment the percentage of time spent in hospital progressively fell (Table 1).

These figures indicate that a considerable number of hospital beds must be available for the maintenance of a dialysis unit. In the London Hospital this has necessitated the use of an average of 10 hospital beds at any one time, but this figure does not include patients admitted for assessment and found unsuitable. The total number of days spent in hospital by the 37 patients accepted (including the predialysis period of assessment) was 2,012. In our experience between 15 and 20 hospital beds had to be available. It is a fallacy to assume that the financing of a dialysis unit alone is sufficient to support a dialysis programme. The need for additional supporting beds will, moreover, progressively increase as more patients are transferred to home dialysis.

TABLE 1.—Time Spent in Hospital by Patients Receiving Regular Dialysis Treatment. Time Spent as an Inpatient Before Starting Regular Dialysis Treatment (Period (1) in Text) is Not Included. Time Spent in Routine Twice-weekly Hospital Attendance for Dialysis is also Excluded

Duration of Regular Dialysis Treatment	No. of Patients	Average Duration of Treatment (Days)	Average No. of Admissions	Average Total Duration of Inpatient Admissions (Days)	Average Duration of Each Admission (Days)	Percentage Time in Hospital
All patients	37	174	2.5 (1-7)	32.5 (5-96)	13	18.7
Patients treated for:						
Less than 100 days	12	53.3	1.3 (1-3)	28.8 (7-81)	22	54
100-300 days	16	169	2.6 (1-5)	39 (12-96)	15	23.3
More than 300 days	9	346	4 (1-7)	26 (5-52)	6.5	7.5

Materials and Methods

Treatment Schedule

In hospital, patients were dialysed for 28 hours per week in two nightly periods of 14 hours. At home, patients were dialysed three times a week for 10 hours. Dietary protein was restricted to 0.75 g./kg. ideal body weight per day (Ellis, 1968; Shinaberger and Ginn, 1968). In all hypertensive patients the daily sodium intake was restricted to 20mEq. When blood pressure control was achieved the sodium intake was adjusted to 40 mEq daily and then gradually increased by further 10-mEq increments as long as blood pressure control was maintained. The final sodium intake was adjusted according to the daily urinary sodium excretion. Water intake was limited to 400 ml. plus mean daily urine volume and potassium to 60 mEq/day. Patients were encouraged to take a 3,000-calorie diet; this was achieved by daily supplements of 4 oz. (113 g.) of salt-free butter, 4 oz. of sugar, and 4 oz. of double cream. On this diet the intake of calcium was about 500 mg./day and that of iron 11 mg./day. No vitamin, iron, or calcium supplements were given routinely.

This diet—including the sodium restriction—was maintained even when the patient was actually undergoing dialysis. Since the main difficulty with the diet was the lack of salt, the patients considered that if they remained on salt-free food alone for a period of time they eventually became used to it and no longer craved for salt. Furthermore, if they were allowed salt during the time they were on dialysis they were never happy eating a salt-free diet between dialyses. It was for this reason that relaxation of salt restriction was *never* encouraged.

Equipment

Water was softened, both in the unit and at home. Dialysate was originally prepared in bulk, in large tanks, and fed by gravity from a header tank to a central supply system. This system was later replaced by single-pass, single-patient machines. Modified Kiil dialysers were used throughout with Cuprophane PT150 membranes.

All the equipment failed at some time, with occasionally serious consequences. The unit water-softener failed to recharge on one occasion and four patients were inadvertently dialysed against a calcium concentration of 16 mg./100 ml. and developed the "hard-water syndrome" (Freeman *et al.*, 1967; Drukker, 1969) of nausea, vomiting, and severe hypertension. Though regular testing of water hardness is now carried out, no entirely satisfactory method of detecting water-softener failure during dialysis has been found. Such failure has occurred in home dialysis machines and is a serious potential danger.

Another particularly troublesome problem, especially in winter, was dissolved air in the incoming water supply. This came out of solution on warming, passed across the membranes, and accumulated in the blood compartments and bubble traps. Dialysis became less efficient, and the level of blood in the bubble traps required frequent adjustment (Parsons and Meffan, 1969), thus increasing the risk to the patient of air embolus. Makeshift de-aeration devices were used in the home and a central de-airing system was installed for the unit water supply. Photoelectric devices (Berlyne *et al.*, 1968) for detecting a fall in level of the blood in the bubble trap were unsatisfactory in practice. A further problem encountered was the inadvertent use of a 2% formalin solution to sterilize the Kiil dialysers which led to severe pyrogenic reactions in a number of patients. A change to 2% formaldehyde, however, eliminated the problem (Murray *et al.*, 1969).

Clinical Aspects

Blood pressure

Before dialysis treatment was started 76% of all patients had significant hypertension—that is, blood pressure above 160/90 mm.Hg, taken by sphygmomanometry in the arm with the patient recumbent—and 43% had blood pressures higher than 200/120 mm.Hg. (Table II). Significant hypertensive retinopathy before dialysis was present in 57%, 44% having severe changes with either papilloedema, haemorrhages, or exudates (Table III). One or more hypotensive agents, either with or without a diuretic, were given to 54% of patients.

TABLE II.—Distribution of Blood Pressure Measurements Made in the Recumbent Position in Patients Before and Three, Six, and Nine Months after Starting Regular Dialysis Treatment

	No. of Patients	Blood Pressure				
		<u>160</u>	<u>161 180</u>	<u>181 200</u>	<u>200</u>	
		< 90 %	91 110 %	111 120 %	> 120 %	
Before dialysis	37	24	19	14	43	
3 months' dialysis	25	67	29	4	0	
6 months' dialysis	15	71	29	0	0	
9 months' dialysis	10	60	40	0	0	

TABLE III.—Hypertensive Retinopathy (Classification of Keith *et al.*, 1939) in Patients About to Start Regular Dialysis Treatment

Grade	No.	0	I	II	III	IV
Patients {		16	4	1	8	8
%		43	10	3	22	22

All hypotensive drug therapy was discontinued when patients were started on regular dialysis treatment. Blood pressure control was achieved by removal of salt and water by dialysis—often with a considerable reduction in body weight—and by strict dietary sodium restriction (see Treatment Schedule).

Three months after dialysis treatment was started reasonable control of blood pressure—measured immediately before each dialysis—was achieved in most patients (Table II). Six months after dialysis treatment no patient had a blood pressure above 180/110 mm.Hg and 71% of patients were considered normotensive. In no case was it necessary to recommence regular hypotensive drug therapy. Papilloedema resolved and haemorrhages and exudates disappeared in every case. It has therefore been possible to achieve blood pressure control by dietary sodium and water restriction and by dialysis (Comty *et al.*, 1964; Shaldon, 1966). Furthermore, in the period reported on here no patient has required nephrectomy for the achievement of blood pressure control.

Blood Transfusion Requirements

Owing to the outbreaks of hepatitis in other dialysis units (Lancet, 1965, 1969; Drukker *et al.*, 1967) it was decided to withhold blood transfusion except where acute and severe blood loss or incapacitating symptoms of anaemia occurred. This policy was also pursued to prevent the development of antibodies which might interfere with future renal transplantation (Dausset, 1958; Parsons and Clark, 1969). Eighty-one units of blood were transfused during 229 patient months, an average of 0.35 units per patient-month (Curtis *et al.*, 1969). At the end of the year the average packed cell volume of all patients was 22.3% (males 23.5%; females 20.2%). No case of hepatitis occurred in either patients or staff. Prophylactic human gammaglobulin was not given.

Biochemical Analysis

The following investigations were carried out before regular dialysis treatment was started, and thereafter monthly blood

TABLE IV.—The Effect of Regular Dialysis Treatment on Blood Biochemistry. Values Shown are Means $\pm$ Standard Errors of the Means

	No. of Patients	Plasma Urea Concentration (mg./100 ml.)	Plasma Creatinine Concentration (mg./100 ml.)	Plasma Uric Acid Concentration (mg./100 ml.)	Plasma Calcium Concentration (mg./100 ml.)	Plasma Phosphorus Concentration (mg./100 ml.)	Calcium $\times$ Phosphorus Product
Before dialysis	37	317 $\pm$ 22.3	20.6 $\pm$ 1.2	12.1 $\pm$ 0.7	8.1 $\pm$ 0.3	11.9 $\pm$ 1.1	96
During first 3 months' dialysis	27	141	12.1	10.6	9.0	7.9	71
During second 3 months' dialysis	14	155	13.4	11.0	9.1	7.8	71
During third 3 months' dialysis	7	141	14.2	9.8	9.2	8.6	79
During entire 12 months' dialysis	31	148 $\pm$ 7.8	12.5 $\pm$ 0.6	10.3 $\pm$ 0.3	9.0 $\pm$ 0.4	7.9 $\pm$ 0.4	71
During entire 12 months' dialysis (males)	22	153 $\pm$ 9.6	13.3 $\pm$ 0.6	10.9 $\pm$ 0.4	8.9 $\pm$ 0.1	8.0 $\pm$ 0.6	71
During entire 12 months' dialysis (females)	9	137 $\pm$ 12.7	10.8 $\pm$ 0.8	9.4 $\pm$ 0.3	9.1 $\pm$ 0.2	7.3 $\pm$ 0.8	66

samples were taken immediately before dialysis for estimations of plasma electrolyte, urea, creatinine, uric acid, calcium, phosphorus, alkaline phosphatase, and protein concentrations. Each month measurements were also made of 24-hour urine volume, and electrolyte and urea excretions. The effect of regular dialysis treatment on plasma urea, creatinine, uric acid, calcium, and phosphorus concentrations is shown in Table IV. Results obtained after home dialysis had been started are not included. As only four patients completed 12 months of hospital dialysis the figures for the tenth to twelfth months of dialysis have not been analysed separately. Those patients who received less than two months' dialysis have been excluded from the table except for an analysis of their results before regular dialysis treatment was started.

The male patients had higher mean values of plasma urea, creatinine, uric acid, and phosphorus, but a slightly lower mean calcium concentration than the females (Table IV). The differences, however, are not significant. The high level of plasma phosphorus was noted during the year and in some cases necessitated aluminium hydroxide therapy (Mallick and Berlyne, 1968).

Arteriovenous Cannulae

Survival.—Insertion of the arteriovenous cannulae was performed under local anaesthetic by one of the physicians concerned in the care of the patients. The arterial cannula life averaged 8.3 months for the 37 patients (28 replacements in 19 patient years). The venous cannula life averaged 7.3 months (32 replacements). The use of venograms and arteriograms in the precise diagnosis and management of shunt failure has proved of great value (Dathan *et al.*, 1969).

Shunt Infections.—Twenty-nine shunt infections were diagnosed in 14 patients. Of these, 17% occurred within a week of insertion of the shunt and 49% in the first month. There was no significant difference between the incidence of infection in arm or leg shunts. Some patients were given routine antibiotic cover after operation, but there was no evidence that this altered the development of shunt infections in the immediate postoperative period. *Staphylococcus pyogenes* was by far the most common pathogenic organism isolated, being cultured in 12 of the 29 shunt infections; in seven of these the organism was penicillin-resistant.

Conclusions

A great deal of money and time has been spent in the treatment of a relatively small number of patients. With the rapid expansion of the unit, however, experience and knowledge have been gained. Though the degree of rehabilitation of the patients is satisfactory, their health remains very precarious. Since readmissions to hospital are usually the result of failure of arteriovenous cannulae, the arteriovenous fistula described by Brescia *et al.* (1966) provides a welcome alternative, though insufficient time has yet passed for its full assessment. Access to the circulation remains one of the outstanding problems of chronic haemodialysis today.

Now that the survival rate of patients is increasing as a result of the successful control of hypertension, more long-term problems such as metabolic bone disease, neuropathy, and anaemia are emerging and necessitate further study. As increasing numbers of patients are accepted for transplantation or maintained on home dialysis, the need for an adequate number of back-up beds associated with each dialysis centre will increase proportionally. Similarly, more medical and technical staff will be needed to cope with the increasing work-load.

The design of new dialysers is an exciting challenge. It is hoped that the future will produce new principles and methods which will make dialysis treatment cheaper, more efficient, more convenient for the patient, and less time-consuming for the medical staff.

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