a complication of the obstruction. If there is any question of a high intestinal obstruction the diagnosis may be confirmed by inserting 15 ml. of 60% urographin down a Ryle tube (Case 1, Fig. 2).

The sudden onset of symptoms occurring with obstruction of the jejunum is usually due to an associated perforation, to the development of an intussusception, or if there is a sudden occlusion of the lumen of the bowel. The two cases described above demonstrate the first two methods of onset of symptoms.

The copious vomiting produced by obstruction high in the intestinal tract causes a rapid alteration in the normal fluid and electrolyte balance, and the subsequent salt-and-water depletion may result in renal failure. This must be distinguished from the sodium, chloride, and water deficiency due to renal failure (de Wardener, 1958). When salt deficiency is secondary to renal failure, the urinary specific gravity is around 1010, whereas if the kidneys were previously normal tubular function will remain normal and the specific gravity will at first be greater than 1020. If, however, the vasoconstriction persists and acute renal failure develops, the specific gravity will fall towards 1010. In chronic pyelonephritis or glomerulonephritis the syndrome is sometimes known as "salt-losing nephritis."

In Case 1 spontaneous recovery of renal function returned with the institution of an intravenous infusion replacing the fluid and electrolyte deficiency. In Case 2 oliguria persisted after the fluid deficiency had been replaced by an intravenous infusion and continued for a total of 28 days. This indicated that the renal failure was not simply secondary to the intestinal obstruction, but that there was also primary intrinsic renal parenchymal damage. In this case it was possible by the aid of two dialyses with the artificial kidney, each of six hours' duration, to restore the electrolyte imbalance to approximately normal levels until renal function returned spontaneously. Haemodialysis also made it possible to deal with the perforation and high intestinal obstruction safely by operation during the period of uraemia.

Laparotomy with intestinal resection was carried out in both these cases only after the fluid and electrolyte imbalance had been corrected as well as possible. This may be done by simple intravenous therapy, but if there is any associated renal damage extracorporeal haemodialysis should be considered. A review of 27 years' experience with jejunal neoplasm dealt with by operation has put the mortality for such cases at 16% (Pridgen *et al.*, 1950), and it would seem that by earlier diagnosis and the modern methods available to correct fluid and electrolyte imbalance the mortality figure should be greatly reduced.

Summary

Two cases of jejunal obstruction are described. The first presented as an intussusception caused by a primary carcinoma and the other as a perforation of the distended jejunum above a band adhesion.

Both patients showed severe fluid and electrolyte imbalance, which had to be corrected before it was possible to carry out successful resection of the obstructions. Intravenous therapy alone was sufficient in one case, but as the other was associated with intrinsic renal damage it was necessary to correct the electrolyte imbalance on two occasions by dialysis with the artificial kidney.

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A WEIGHING-BED: ITS CONSTRUCTION AND USE IN HAEMODIALYSIS

BY

JACK NAYMAN, M.B., F.R.C.S., F.R.C.S.Ed.

University of Melbourne, Alfred Hospital

The connexion of the vascular system of the organism to an extracorporeal circuit, with the inclusion of a dialysing membrane for the purpose of haemodialysis, invokes a particular chain of events which affect the distribution and volume of the body fluids.

There may be an imbalance in the outflow and inflow rates of blood, resulting in hypervolaemic or hypovolaemic states. The patient may be bleeding either as a result of uraemia or as a consequence of systemic heparinization. The added volume of the extracorporeal circuit is countered by prior priming with bank blood. There are, however, two specific factors which have to be taken into account in the use of the disposal twin-coil Kolff kidney. The first is the capacity of the coil itself, and the second that of ultrafiltration.

When the machine is primed the coil is filled with a volume of blood which is the static volume. In connecting the patient to the extracorporeal circuit the coil distends. This increase in capacity (dynamic volume) results in a depletion of the patient's blood volume, and is manifested by a drop in blood-pressure. This initial hypotension is a common occurrence, and it is important to correct and anticipate its development. Blood can be transfused into the extracorporeal circuit. The twin-coil Kolff kidney utilizes the principle of ultrafiltration whereby considerable quantities of water can be removed.

Thus, in summary, there can be an imbalance in outflow-inflow rates, the patient can bleed, the dynamic-static volume difference can cause hypotension, blood can be transfused, and fluid can be removed by ultrafiltration.

The importance of having a simple means of assessing and correlating these changes with a view to effective management during haemodialysis is apparent. It was felt that weighing the patient should be able to afford the necessary help in this respect.

Although Wangenstein (1947) and Merrill (1955), among others, have stressed the importance of weighing in the management of fluid balance, its routine use has not received wide application. This can be explained to a large extent by the cumbersome and complex weighing structures commonly in use, many of which involve a most complicated procedure in taking a reading (Wangenstein, 1947; Alwall, 1952; Hamburger and Mathé, 1952).

The construction of a weighing apparatus for use during haemodialysis must be determined by, and should comply with, the following criteria: (1) accuracy,

(2) simplicity of construction, (3) mobility and manoeuvrability, (4) ease of operation, (5) economy of manufacture, (6) no disturbance to patient, and (7) technique of haemodialysis should continue unhindered. These requirements could be fulfilled only by incorporating the weighing mechanism into the general structure of a bed. The final design of the weighing-bed is depicted in Fig. 1.

The principle involved is considered; the efficacy and suitability are evaluated in relation to the above-

FIG. 1.—Weighing-bed.

mentioned criteria; and, finally, some points in its clinical application are detailed.

Clinical Application

The conventional platform scale with balance arm has a non-weighing and a weighing position. In the former the platform is so adjusted that there is no contact between a ball-rest on its under surface and a reciprocal socket which is connected to the balance arm (Fig. 2 A). In the weighing position the platform is depressed by the weight, direct contact between this rest and socket is established, and the appropriate reading is taken (Fig. 2 C). The mattress and supporting platform of the bed is fixed permanently to the platform of the scale by angled girders. The non-weighing position is simulated by preventing direct transmission of weight to the scale platform and transferring this weight direct to the framework of the bed. This is facilitated by two supporting rods of metal at each end.

FIG. 2.—Diagram of platform scale with balance arm in non-weighing (A, B) and weighing positions (C, D).

By means of attached arms these rods can be adjusted so as to take the weight of the bed (Fig. 2 B). Inward rotation of these arms removes this support and the weight is transmitted direct to the platform of the scale (Fig. 2 D).

The dimensions are shown in Fig. 3. For a reading to be taken the patient should be balanced so as to lie in a horizontal axis. Two factors have to be taken into account. Firstly, the centre of gravity of the body is roughly 3 in. (7.5 cm.) nearer the head end, and this factor is taken into account by placing the mid-point of the scale platform 3 in. (7.5 cm.) nearer the head end than the mid-point (M in Fig. 3) of the bed. Secondly, there is a great variation in the weight of the individual patient as well as in the position in which the patient is placed on the bed. For example, it is necessary to support a patient with pulmonary oedema by pillows in a sitting position. These variations are countered by being able to move the bed platform in both directions in this longitudinal axis by means of rollers as illustrated in Fig. 4.

This design is simple in construction, has great mobility and manoeuvrability, and, in addition to the cost of the scale (£A50), involved an outlay of only £A38. It is particularly easy to operate, merely requiring the inward rotation of the rod arms, and there is no disturbance to the patient or any interference with the technique of haemodialysis (Fig. 5).

FIG. 3.—Dimensions of weighing-bed. M=Mid-point.

FIG. 4.—Rollers for moving bed platform.

The accuracy was assessed by the withdrawal and infusion of fixed quantities of blood from the respective cannulated femoral artery and vein of an anaesthetized dog. Fixed 20-ml. volumes of blood were removed at fixed time intervals and corresponding readings on the scale noted.

After this, the 20-ml. quantities were injected at the same time-intervals and corresponding readings taken. The graphical representation of these changes is depicted in Fig. 6. This shows a fairly close relation between fairly small changes in blood volume and the weight-recording of the scale, the withdrawal or injection of 20 ml. being proportional to one division on this particular scale (1 oz.). This scale had been purchased some years ago for a purpose where calibration in pounds and ounces was desired. The horizontal lines on this graph can be explained on the basis of experimental error of the balance arm of the scale and of the visual acuity of the observer.

This weighing-bed has been used in 28 dialyses (13 patients). The accompanying Table relates the weight changes and other relevant data:

The ages vary from 7 years to 77 years, the initial weights from 41 lb. 3 oz. to 197 lb. 4 oz. (18.7 to 89.5 kg.), and the duration of dialysis from one to eight hours. Ultrafiltration was instituted in four cases (Nos. 3, 7, 8, and 12) and the respective loss of fluid was 6.1%, 3.8%, 7.7%, and 2.3% of the total body weight.

An Important Point

The state of hydration prior to dialysis was an important determinant in the approach to replacement of fluid. It must be appreciated that there is a loss of weight over the period of dialysis as the patient is virtually starving.

In Case 4 the patient was obviously overweight for her height, and her first dialysis resulted in a loss of 2.8% of her body weight and her second dialysis in a loss of 2.2%. When she was dialysed on the third occasion she was anaemic. Initial transfusion of blood was given, there was then a progressive loss which was largely replaced before the end of dialysis. The net result was a loss of 0.7% body weight. These events are depicted in Fig. 7. Her total weight loss between

her first and fourth dialysis (three weeks) was 13 lb. 11 oz. (6.2 kg.). She was discharged fit and well.

In Case 7 the first dialysis was discontinued after one hour. On the second occasion, 3.8% of body weight was removed (ultrafiltration) and 2.6% on the third occasion. It was important to prevent any further losses subsequently, and, as the patient was anaemic, blood was transfused with each further dialysis.

It is significant to note that in the latter series, where regional heparinization was used, the average loss in

FIG. 5.—Weighing apparatus in use, showing inward rotation of rod arms.

nine instances was only 0.01% of the total body weight. This is partly due to the continuous infusion of fluid for the administration of heparin and protamine sulphate.

Conclusion

This weighing-bed has been of immense help during haemodialysis. It gives us a fairly accurate indication of the state of hydration of the patient and there is a correlation between the dynamic-static volume difference and the initial hypertensive phase. It facilitates early recognition of any fluid loss or bleeding and measures the accuracy of their replacement. It is of particular

FIG. 6.—Graphical representation of withdrawal and injection of fixed quantities of blood at fixed time intervals.

FIG. 7.—Case 4. Dialysis of six hours, showing total loss of 1 lb. 10 oz. (0.74 kg.) from weight of 160 lb. 8 oz. (72.8 kg.).

Details of Cases

Case No.	Diagnosis	Age and Sex	Duration of Dialysis in Hrs.	Date	Weight						% Loss of Body Weight	Remarks
					Before Dialysis		After Dialysis		Loss			
					lb. oz.	kg.	lb. oz.	kg.	lb. oz.	kg.		
1	Polyarteritis nodosa	9 F	5 5½	29/4/61 11/5/61	43 14 41 3	19.9 18.7	42 0 39 12	19.0 18.0	1 14 1 7	0.85 0.65	4.4 3.5	Oedematous
2	Multiple fracture. Staph. septicaemia	58 M	7 8	1 5/61 4/6/61	197 4 193 5	89.5 87.7	192 13 189 10	87.5 86.0	4 7 3 11	2.01 1.67	2.2 1.6	
3	Transurethral resection	72 M	7 8	19/5/61 25/5/61	141 0 126 7	64.0 57.4	132 5 122 2	60.0 55.4	8 11 4 5	3.94 1.95	6.1 3.4	
4	Septic abortion. <i>Cl. welchii</i>	27 F	7½ 7½ 7½ 6½	31/5/61 7/6/61 14/6/61 21/6/61	172 9 170 7 162 2 160 8	78.3 77.3 73.5 72.8	167 12 166 10 161 1 158 14	76.1 75.6 73.0 72.1	4 13 3 13 1 1 1 10	2.18 1.73 0.48 0.74	2.8 2.2 0.7 1.0	Very obese
5	"Open heart" operation	7 M	4	13/6/61	44 1	20.0	43 12	19.8	0 5	0.14	0.7	
6	Pancreatitis. Perforation stomal ulcer	58 M	7½	18/6/61	169 1	76.7	169 8	76.9	+0 7	+0.20	+0.3	
7	Subacute nephritis	38 F	1	18/7/61	135 14	61.7	135 14	61.7	0 0	0	0	Pulmonary oedema
			5	21/7/61	132 0	59.9	127 0	57.6	5 0	2.27	3.8	
			5	25/7/61	122 12	55.7	119 8	54.2	3 4	1.47	2.6	
			6	29/7/61	118 0	53.5	118 1	55.6	+0 1	+0.03	+0.05	Regional heparinization (R.H.)
			4	3/8/61	114 14	52.1	114 14	52.1	0 0	0	0	
			4½	7/8/61	113 11	51.6	114 7	51.9	+0 10	+0.28	+0.5	
8	Acute-subacute nephritis	8 F	6 4	19/7/61 11/8/61	52 14 49 15	24.0 22.6	48 13 48 6	22.2 21.9	4 1 1 9	1.84 0.71	7.7 3.1	Oedematous
9	T.U.R.	77 M	5½ 6	26/7/61 1/8/61	180 6 167 10	81.8 76.0	178 12 167 13	81.1 76.1	1 10 +0 3	0.74 +0.09	0.9 +0.1	R.H.
10	T.U.R. septicaemia	75 M	6 6½	25/8/61 30/8/61	185 0 179 6	83.9 81.4	184 14 179 3	83.8 81.3	0 2 0 3	0.56 0.09	0.06 0.06	"
11	Pancreatitis	66 F	4	11/9/61	163 10	74.2	164 9	74.6	+0 15	+0.42	+0.6	"
12	Extrarenal obstruction	50 F	7	13/9/61	138 3	62.7	135 0	61.2	3 3	1.45	2.3	"
13	Salt-losing syndrome	26 M	5½	15/9/61	140 8	63.7	141 1	64.0	+0 9	+0.26	+0.4	"
			7	20/9/61	136 8	61.9	135 12	61.6	0 12	0.34	0.6	

benefit in children and in patients submitted to multiple dialyses.

There is only one occasion when the bed could not be used: in the case of a 16-year-old boy who was quadriplegic as a result of fracture-dislocation of his cervical spine; he was in traction and nursed on a special spinal bed.

It does appear that such a weighing-bed would be of benefit in the routine management of surgical (post-operative and loss from fistulas, etc.) and medical (cardiac failure, etc.) cases.

Summary

In the management of haemodialysis a knowledge of the fluid changes is of fundamental importance.

The method of estimation should be simple in performance, accurate in assessment, and free of complex procedures and manipulations.

The principle of weighing the patient in the management of fluid balance has been recognized for a considerable time.

This method has not received wide application owing to the cumbersome and complex designs of the models in use.

The requirements for a weighing-bed for use during haemodialysis are detailed, taking into account the above factors.

A weighing-bed, designed and developed in this unit, which fulfils these requirements is described.

The experience in 28 dialyses is presented.

The routine use of such a weighing-bed in the management of fluid balance in medical and surgical cases is suggested.

I would like to express my thanks and appreciation to the engineering department of the Alfred Hospital for the construction of this bed and to Mr. Raymond Sparks for help in the design. This work was undertaken in the

department of surgery, and I thank Professor Ewing for facilitating its development and for his help with the manuscript.

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The Minister of Health, Mr. Enoch Powell, speaking at the opening on March 15 of a new adult training centre for the mentally subnormal, provided by the Middlesex County Council at Claverings Estate, Edmonton, said: "Those of us who have a special concern for the mentally handicapped—I say 'us' advisedly, for I number myself among them—are living in a hopeful time. Not in one direction, but in many at once, development and experiment are going forward, so that what until almost yesterday was perhaps the most neglected corner of the field has become one of the major 'growing points' of our health and welfare services. The long-term plan for the hospital service, which was published in January, shows that over the period of the plan the number of hospital beds for the mentally subnormal will increase by about 4,000 from 60,000 to 64,000. But this comparatively modest increase gives little indication of the scale of improvement which is planned in this part of the hospital service. The total number of new beds provided—in newly built or fundamentally remodelled premises—will be over 12,000, or no less than one-fifth of the whole number, so that many thousands of places in the oldest and most unsuitable accommodation will be eliminated and replaced. This is not counting the improvements—often far-reaching—in the premises which will be retained. . . . An appendix to the hospital plan attempted to offer some statistics of local authority health and welfare services. It showed that, while to every 100,000 of the population there were 130 hospital beds for the subnormal, there were already 43 places in training centres at the end of 1960. That figure is already out of date. New centres are being opened at a rate approaching one a week, and at this moment no fewer than 220 further new centres are in the plans of local authorities."