Automatic Production of Dialysing Fluid

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The provision of adequate quantities of safe dialysing fluid for artificial kidneys has always been a problem. The introduction of single pass machines such as the Kiil and Longmore dialysers has posed the additional problem of providing large volumes of fluid not only in renal units, general wards, and the patient's home, but also in cardiac units since the recent extension of the use of the Longmore unit in heart failure.

Thus the requirements may vary from 0.5 l./minute for one machine to 5 l./minute for a 10-bedded renal unit, requiring a total of up to 5,000 l. of fluid during a 15-hour working day.

The ideal dialysing fluid should be of the correct electrolyte content for the patient, of a minimum bacterial content, of the correct temperature, at a suitable working pressure, air-free, produced automatically, and produced from a compact and silent machine. The most satisfactory way to do this is to use tap-water mixed with a concentrate of electrolytes in the correct proportions but some 30 to 40 times the strength required.

The unit described below provides only one mix, but modifications are available which can provide additional variants such as *p*H and potassium concentration. These variants are specifically required for the management of heart failure in cardiac units.

The unit was designed to produce ideal dialysing fluid with simplicity and reliability in mind. Each component can be serviced or replaced by either a physician or technician, for no expert electronic or engineering help is required. The unit is fail-safe and fully monitored.

The Apparatus

The components of the mixer are self-contained and assembled in such a manner that they can be either mounted in racks on a wall or in a wheeled cabinet 4 ft. 6 in. (1,370 cm.) high by 2 ft. by 2 ft. (61 cm. by 61 cm.). This has been done so that only the components required for a given environment need be used. If the usage of the mixer varies—for example, a dialysis unit with more than 10 beds—it can be modified by the addition of sub-units only, all of which are described below.

Mixer Unit

The heart of the apparatus is a jet pump. The motive power is provided by the water-supply to the main jet, which is controlled by a pressure-reducing valve and high- and low-level stops in the mixing-tank. The side arm of the jet pump sucks concentrate through a calibrated jet. The flow of concentrate is regulated by a solenoid valve actuated by an electric conductivity meter which has its temperature-compensated measuring-cell situated in the mixing-tank.

The "concentrate-solution" is kept in 25-l. or 50-l. polyethylene aspirators fitted with an airtight screw-cap. The tip of the aspirator dips into a plastic tray, thereby maintaining a constant head of concentrate-solution into which the side arm of the jet pump is placed. A warning device is fitted to indicate if the volume of concentrate-solution reaches a low level.

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Concentrate-solution

A set of three interchangeable jets for the side arm of the pump is provided, one for each range of concentrate of electrolytes 25-30, 30-35, and 35-40. Once the strength of the concentrate is chosen and the correct jet put in no further maintenance of this unit is necessary. Furthermore, the conductivity meter will correct for an error of ± 10% in the water content of the concentrate. The final strength of the dialysing fluid is selected on a calibrated dial.

Water-supply

The jet pump requires a constant-pressure water-supply. If the mains water-pressure is inadequate and likely to fall below 20 lb./sq. in. (1,033 mm. Hg), a booster pump is fitted. If the hospital hot-and-cold-water supply has adequate pressure, then a thermostatically controlled mixer-valve can be used. If the hot-water supply is not suitable thermostatically controlled electric heaters can be installed in the cold-water supply line. If the water supplying the mixer has a calcium or magnesium content that is too high a deionizer is installed and the composition of the concentrate adjusted accordingly.

"De-airer"

When cold water from the mains is heated to body temperature and subjected to a negative pressure in the dialyser air comes out of solution and may well interfere with the efficiency of dialysis, reducing the effective surface area of the membrane and causing air locks.

A thermostatically controlled mixer-tap using hot water may reduce the quantity of air below the critical level, but if cold water has to be used it is necessary to consider methods for the further removal of air. The jet pump used in this unit has a low-pressure area and air comes out of solution at this point. The jet pump is arranged so that cavitation does not occur, for the pressure never falls below the water-vapour pressure. The jet pump discharges near the edge of the mixer-tank, forming a vortex in the tank, and any dissolved air which comes out of solution in the jet pump passes to the centre of this vortex and bubbles off. Nevertheless, in occasional stubborn cases it is necessary to take further steps to remove air, and in order to do this a small combined venturi-and-vortex unit has been evolved. This combines the principles of a low-pressure zone from a venturi with a small-diameter vortex, throwing released air to the centre. When this unit is installed it sucks the dialysate from the bottom of the mixer-tank and discharges it from a tube parallel to the main jet pump inlet tube, increasing turbu-

lence. The suction-hole for this small vortex-venturi unit is placed just below the cell of the electric conductivity meter and helps scour this of small bubbles and also ensures a good flow of fluid through it.

Distribution of Dialysate

When the dialysate leaves the mixing-tank it passes into a delivery-tank which has an electric-heater element that may be used either to bring the dialysate up to temperature or for sterilizing the installation before use. The whole of the apparatus is made of materials which can stand chemical or heat sterilization, and it can be fitted with provision for either kind of sterilization. The components are all placed, either in the cabinet or in the rack for wall-mounting, in such a manner that each can be serviced in its place separately. The final mix is guarded by a second electric conductivity meter which can be set so that if its readings do not agree with the primary meter the alarm is set and the fluid is run direct to waste until the composition of the fluid returns to normal. A ring main can be provided to run round the ward if the unit is to be maintained permanently, or semi-permanently. Alternatively, multiple feeds can be plugged in if the mobile cabinet model is used.

The mobile cabinet model has had a clinical trial, and has proved to be reliable and satisfactory. The accompanying Table shows the constancy of the sodium concentration in the dialysing fluid. The electric conductivity meters have measuring-cells made of carbon-graphite composition and are robust, and have electrical constants of indefinite stability. They are unaffected by temperatures up to 80° C., by 2% formalin, or by 3% acetic acid. They require cleaning with detergent about once a month, and, if they are accidentally damaged, cells with identical characteristics are available and may be kept as spares.

Sodium Concentrations of Dialysis Fluid

		Na mEq/l.	Dial Set to Give
2 Feb. 1966	3.30 p.m. (initial)	130	130 mEq/l.
	4.00	130	
	4.30 p.m.	130	
	4.45 p.m.	131	
9 Feb. 1966	9.30 a.m. (initial)	130	130 mEq/l.
	10.30 a.m.	128	
	11.30 a.m.	130	
	12.30 p.m.	130	
	1.30 p.m.	128	
	2.30 p.m.	130	
	3.30 p.m.	130	
	4.30 p.m.	128	
10 Feb. 1966	9.30 a.m.	127	130 mEq/l.
	10.30 a.m.	129	
	11.30 a.m.	130	
	12.00 noon	128	
	12.20 p.m.	135	135 mEq/l.
	2.00 p.m.	136	
	3.00 p.m.	120	120 mEq/l.
	4.00 p.m.	120	130 mEq/l.

Summary

A machine for the automatic production of dialysing solution is described. The unit is based on a jet pump which adds a metered quantity of dialysing concentrate to tap-water. This unit has been in clinical use twice weekly for six months, and has been employed for over 150 dialyses in conjunction with the Longmore artificial kidney. It has been checked weekly for stability and found to be satisfactory.

The apparatus is manufactured by Medtec Tools Limited, 271 Argyle Avenue, Slough Trading Estate, Bucks, and we wish to thank Mr. Philip Allen, of Medtec, for the careful work which has gone into the manufacture of the prototypes. The cost of the unit varies with specification from £600 to £1,000.

Felty's Syndrome. Good Response to Adrenocorticosteroids: Possible Mechanism of the Anaemia

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The combination of chronic arthritis of the rheumatoid type, splenomegaly, anaemia, leucopenia, and often lymphadenopathy is known as Felty's syndrome (Felty, 1924).

The response of the blood abnormalities to adrenocorticosteroids is variable, but sustained improvement appears to be uncommon (de Gruchy and Langley, 1961). de Gruchy (1964) frankly states that they are ineffective. Splenectomy is often of considerable value (Hutt *et al.*, 1951; de Gruchy and Langley, 1961; Hume *et al.*, 1964) but tends to be hazardous, especially in the elderly patient.

The following case report illustrates a good response to adrenocorticosteroids, and studies of red-cell and plasma volumes and of red-cell survival with radioactive chromium (^{51}Cr) have served partially to elucidate the mechanisms by which the haematological improvement took place.

Methods

Occult blood tests: the amidopyrine method of Harrison (1957). Red-cell survival: method of Mollison and Veall (1955) (^{51}Cr) after Pengelly and Wilkinson (1962). Mean red-cell life-span was calculated by method A (Mollison, 1956). Packed red-cell volumes: method of Wintrobe (1933). Red-cell volumes: method of Mollison and Veall (1955), blood samples being taken 25 and 30 minutes after injection of the ^{51}Cr-labelled red cells. Whole blood volume was calculated by assuming a whole body to peripheral haematocrit ratio of 0.91 (Gibson *et al.*, 1946; Chaplin *et al.*, 1953), the peripheral venous haematocrit having been corrected for trapped plasma by the method of Chaplin and Mollison (1952). The plasma volume was taken as the difference between whole blood and red-cell volume.

Case Report

A labourer aged 68 developed arthritis at the age of 47. Despite considerable deformity of his hands and feet he was able to work for 15 years until he was declared redundant. On 11 November 1964 he was admitted to the Grange Hospital, Weaverham, with bronchitis.

On examination a small pale man was seen with gross chronic rheumatoid changes in the hands, wrists, elbows, knees, ankles, and feet, and large nodules near the elbows. Scattered rhonchi were

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