AUTOMATIC PERITONEAL DIALYSIS

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An automatic peritoneal dialysis machine* which is on exhibit at this meeting was first described in 1964 (McDonald, 1964) and subsequently this year (McDonald, 1965; and in press). In the inflow period initially unsterile dialysate is pumped through an antibacterial filter directly into the patient's peritoneal cavity. During the outflow period a small suction pump is used on the outflow bottle to augment the outflow rate. The inflow and outflow periods are controlled by preset timers and clamps.

![Graph showing specific gravity vs osmolality](image)

* The automatic peritoneal dialysis machine was made by Sarns Co., Inc., 1354 N. Main Street, Ann Arbor, Michigan, U.S.A.

Fig. 1. The refractometer reading has a straight line relationship with the osmolality for any given dialysate formulation in which a concentrate is diluted with varying amounts of water.

Dialysate

Just prior to the dialysis the dialysate of choice is mixed by adding a 20 to 1 concentrate to prefiltered tap water or to distilled water. A final mixture accurate to ± 8 mOsm can be rapidly determined with a pocket refractometer (Fig. 1).
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Timers
Dial type timers are preset prior to each dialysis in order to achieve desired inflow, pause, and outflow times. Tube clamps are synchronized with the timers to achieve the desired direction of dialysate flow.

Inflow
A Sarns Electronic Pump is activated during the inflow period to pump the initially unsterile dialysate through a 0.22μ Millipore filter and directly to the patient. On the patient’s side of the Millipore filter a closed sterile system is achieved. An inflow rate of one litre per minute is well tolerated. The pump delivers repeatedly within ±2% of the desired volume over repeated cycles.

Tubing
Silastic tubing is used throughout the system and is autoclaved (as is the outflow bottle) before each dialysis.

Pause
A pause period is available on the machine (for ‘equilibration’) if desired. We generally set the pause timer at 0 to obviate this period.

Outflow
During the outflow period a small suction pump is put on the outflow bottle to augment the outflow cycle in a similar manner to Dr. Fred Boen’s peritoneal cycler (Boen, 1964).

Operation
Automatic operation is programmed through the timers. Should manual operation be desired, a manual switch can be used.

Over 50 peritoneal dialyses in rabbits and 26 peritoneal dialyses in humans have been performed with this machine.

PERITONEAL UREA CLEARANCE

Fig. 2. Note that the peritoneal urea clearance increases as the dialysed volume increases.

Clearances with this machine have been previously reported. The clearance of nitrogenous waste products increases as the hourly dialysed volume increases. In the usual ranges of 8 to 10 litres per hour the mean urea clearance is 35 to 40 ml/min; the mean uric acid clearances 25 to 30 ml/min. (Fig. 2).
The cost of dialysate prepared from a concentrate is about one cent per litre. The concentrate is available commercially in any formulation that we desire.

In summary the automatic peritoneal dialysis machine offers several advantages over conventional peritoneal dialysis:

1. Ability to individualize for each patient the dialysate formulation and inflow volumes for maximum effectiveness and comfort.

2. Greater efficiency with higher hourly dialysate flow rates. Less time therefore is required to perform a satisfactory dialysis.

3. The cost of the dialysate is about a penny a litre in that the dialysate is mixed just prior to initiating the dialysis. A regular dialysis program for chronic renal failure using this approach would not be therefore as costly as conventional peritoneal dialysis.

4. Automatic operation. The patient could set or adjust his own machine. The automatic peritoneal dialysis machine might well be used with ease in a home peritoneal dialysis program.

REFERENCES

DISCUSSION

The CHAIRMAN: Now these papers are open for discussion.

Dr. SPAAS (Eindhoven): What is the relation between the urea concentration in the plasma and in the peritoneal dialysate?

Dr. S. T. BOEN (Amsterdam): You can deduce this from the clearance. The clearance calculation includes the concentrations in the blood and in the dialysis fluid.

Dr. SPAAS (Eindhoven): What is the concentration in the peritoneal fluid at high flow rate?

Dr. S. T. BOEN (Amsterdam): Oh, you want to know the exact figure. I think Dr. Tenckhoff can answer this better.

Dr. H. TENCKHOFF (Seattle): I am sorry, I do not have the exact figures, but obviously with high flow rate the concentration in the dialysate outflow will be very low—much lower than with slow dialysis.

Dr. J. SCHIRMMEISTER (Freiburg): The clearance does not depend on the concentration but on the total removal of urea. Therefore it does not depend on whether you have a high volume of fluid and lower concentration, or low volume of fluid and high concentration.

How high did the clearance of urea rise with increasing volume of fluid?

Dr. TENCKHOFF (Seattle): This was, I thought, apparent from the slides. With a flow rate of 2 litres per hour we had average clearances of 20 ml/min. When the flow rate was increased to 10 litres the clearance became 40 ml/min. Does that answer the question?

Dr. S. T. BOEN (Amsterdam): I should like again to congratulate my friend H. McDonald on his work. I believe he is one of the people in this field who has very original ideas. But I should like to make some comments on this automatic machine and particularly on the sterilisation procedure.

The millipore filter that we have tested is very fragile and is very difficult to autoclave. This is one thing we have to keep in mind if we use this kind of system.

Secondly, even if we remove bacteria with this kind of filter with pore size of 0.22 microns, we are not removing pyrogen or virus which may have been left in the water—the filtered tap water—or maybe in the hose where you collect the distilled water. We have seen once, as you know, pyrogenic toxic reaction in a patient using this kind of system, which we have tested in Seattle about one and a half years ago.

I believe incorporation of another filter capable of removing pyrogens, like an asbestos filter, is very important in your system too. We have used this in the last 6 months. There are asbestos filters available which can remove high concentrations of pyrogen.

Dr. H. P. MCDONALD (New York): We have been very much aware of the possibility of pyrogen problems. We have done dialyses on 26 humans with the Automatic Peritoneal Dialysis Machine. After having proven this technique on humans, we have done it on about 30 rabbits. We have not seen pyrogenic reactions. Should the pyrogenic reactions develop with our techniques, we certainly will give strong considerations to the type of asbestos filters that Dr. Boen mentions. Until these reactions occur, we do not see the necessity of adding another bit of equipment to the apparatus.
DISCUSSION

Dr. E. J. Dorhout Mees (Utrecht): I should like to ask Dr. Tenckhoff if he agrees with the conclusion of the Shaldon group that his method of intermittent peritoneal dialysis is a less satisfactory method than haemodialysis and if his experience extends beyond this one patient.

Secondly, I should like to ask if the speeding up of the exchanges does not add to the discomfort of the patient. Is it the same or is there a little increase in discomfort?

Dr. H. Tenckhoff (Seattle): The first question concerning the value of the treatment as compared to haemodialysis. We have 2 patients who have been treated, one for 2½ years and one for 1½ years and recently we have started a few others. Both the longterm patients are doing well. One, for instance, started menstruation after 3 years of amenorrhoea. She has gained, too, in weight. Protein losses are minimised by re-infusion of acidic fluid which accumulates between dialyses and her total serum protein is above 6 g% without infusion of albumin.

The other patient is also well except for the difficulties in blood pressure control I reported on. She maintains her serum protein at 6 g% now. The requirements for blood transfusions have gone down in these patients. The first patient has not had any blood transfusions since January this year, despite re-occurrence of menstruation. Both patients are generally very well.

I might say that I do not think that peritoneal dialysis is acceptable from a psychological standpoint by all patients. Males seem to do psychologically worse on peritoneal dialysis than females. Also, with very big and heavy and very active patients peritoneal dialysis may be insufficient. But certainly in a selected number of patients equally good results may be obtained.

The second question concerned the inflow. As Dr. McDonald mentioned, he pumps the fluid actually into the patient, whereas we let it flow by gravity. We did not see any increased discomfort in the patient.