PERITONEAL DIALYSIS BY ISO-ONCOTIC DEXTRAN SOLUTION IN
ANAESTHETIZED DOGS. INTRA-PERITONEAL FLUID VOLUME AND
PROTEIN CONCENTRATION IN THE IRRIGATION FLUID

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There are two important metabolic problems in peritoneal dialysis: an overloading of the
patient by glucose and a loss of protein into the irrigation fluid. Glucose is added to the
irrigation fluid in order to control the intra-peritoneal fluid volume or to achieve ultra-
filtration (Abbott and Shea, 1946; Grollman et al., 1951); as shown by Boen (1961) and by
others, as much as 700 g of glucose may be reabsorbed per day. Apart from a probably
unfavourable metabolic effect of such an uncontrollable glucose load in uremic patients
who may show abnormalities of carbohydrate metabolism (Westervelt and Schreiner, 1962)
and from hyperglycaemia causing osmotic diuresis with subsequent water and salt depletion,
a rise in plasma potassium concentration may occur after dialysis due to a release of potassium
during the breakdown of glycogen formed during dialysis (Boen, 1961), which is certainly
not desirable in patients with oliguria. As for the loss of protein, it has been shown that the
concentrations of protein in the irrigation fluid may vary between 0.5 and 4.5 g per litre,
and that the total protein loss may amount to more than 100 g per dialysis (Boen, 1961;
Berlyne et al., 1964). Several cases of severe hypoproteinaemia and nephrotic syndrome
secondary to periodic peritoneal dialysis treatment have been reported (Berlyne et al., 1964).

Theoretically it might be expected that an effective control of fluid reabsorption from the
peritoneal cavity could be achieved by replacing glucose by a colloid substance in iso-
oncotic concentration counterbalancing the oncotic pressure of plasma proteins. As there
would be no macromolecule concentration gradient across the peritoneal membrane, a
decrease of the diffusion rate of protein might be expected as well. From this point of view
volume changes of the rinsing fluid and its protein content were studied during peritoneal
lavage in dogs comparing the usual glucose-electrolyte with an iso-oncotic dextran-electrolyte
solution.

MATERIAL AND METHODS

Two types of irrigation fluid were used: a glucose-electrolyte solution (G.E.S., electrolytes
288 mOsm./litre, glucose 83 mOsm./litre, total osmolality 371 mOsm./litre) and an iso-oncotic
dextran-electrolyte solution (I.D.S., electrolytes 288 mOsm./litre, commercial dextran, m.w.
50,000-100,000, 60.0 g/litre, total osmolality about 289 mOsm./litre), the electrolyte
composition of which was the same and practically identical with that of the commercial
Peridial™ solution produced by Cutter Laboratories, Berkeley, Calif., U.S.A. (Table 1).

The experiments were performed in a group of 22 mongrel dogs of both sexes (11.2-32.5
kg b.w.), anaesthetized with Pentobarbital (40 mg/kg b.w.). Their renal function was normal.
In each experiment a pair of dogs of comparable weights was used: one dog received 1000 ml
of the glucose-electrolyte solution, the other one the same volume of the iso-oncotic dextran-
electrolyte solution as irrigation fluid. The fluid was administered and the samples were
collected by means of commercial Peridial™ catheters inserted through a small mid-line
incision in the abdominal wall. Samples of 20 ml of the irrigation fluid were collected every
15 minutes during a period of 1.5 hours; those coloured with blood were discarded. Appropriate mixing was achieved by regular instillations of air and by rhythmic compression of the abdominal wall. In six pairs of animals intra-peritoneal fluid volumes were measured by the method of Razzak, Hassaballa and Naguib (1964) using 8 microcuries of $^{131}$I human albumin per 1000 ml of the rinsing fluid as indicator, and a well type scintillation counter as activity detector. In three pairs of them and in five other pairs of dogs the samples were analysed for protein concentrations using the biuret method of Foster, Rick and Wolfson (1952). In laboratory experiments it was confirmed that the presence of dextran did not interfere with the determination of protein by the biuret reaction. The differences in group analyses were tested for statistical significance by the t-test.

RESULTS

The mean relative intra-peritoneal volume changes of both types of administered solutions are shown in Figure 1. The I.D.S. volumes were remarkably constant, the maximal mean change being +5.13% of the initial volume in the 90th minute, while the G.E.S. volumes showed a progressive increase with a maximum of +24.3% of the initial volume at the end of the observation. However, the difference did not reach statistical significance. The average fluid fluxes were +0.58 and +2.66 ml/min. for I.D.S. and for G.E.S., respectively.

![Graph showing percentage of administered volume over time for G.E.S. and I.D.S.](image-url)
<table>
<thead>
<tr>
<th>Pair of dogs No.</th>
<th>15th minute</th>
<th>30th minute</th>
<th>45th minute</th>
<th>60th minute</th>
<th>75th minute</th>
<th>90th minute</th>
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<tbody>
<tr>
<td></td>
<td>I.D.S.</td>
<td>G.E.S.</td>
<td>I.D.S.</td>
<td>G.E.S.</td>
<td>I.D.S.</td>
<td>G.E.S.</td>
</tr>
<tr>
<td>1</td>
<td>—</td>
<td>—</td>
<td>36.0</td>
<td>66.0</td>
<td>36.0</td>
<td>66.0</td>
</tr>
<tr>
<td>2</td>
<td>—</td>
<td>46.0</td>
<td>—</td>
<td>60.0</td>
<td>—</td>
<td>70.0</td>
</tr>
<tr>
<td>3</td>
<td>20.0</td>
<td>38.0</td>
<td>36.0</td>
<td>54.0</td>
<td>56.0</td>
<td>55.0</td>
</tr>
<tr>
<td>4</td>
<td>12.0</td>
<td>72.0</td>
<td>16.8</td>
<td>88.0</td>
<td>31.2</td>
<td>88.0</td>
</tr>
<tr>
<td>5</td>
<td>30.0</td>
<td>82.0</td>
<td>56.0</td>
<td>96.0</td>
<td>78.0</td>
<td>116.0</td>
</tr>
<tr>
<td>6</td>
<td>26.0</td>
<td>60.0</td>
<td>46.0</td>
<td>108.0</td>
<td>56.0</td>
<td>98.0</td>
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<tr>
<td>7</td>
<td>—</td>
<td>84.0</td>
<td>39.6</td>
<td>112.0</td>
<td>46.0</td>
<td>112.0</td>
</tr>
<tr>
<td>8</td>
<td>24.0</td>
<td>—</td>
<td>22.0</td>
<td>31.2</td>
<td>22.0</td>
<td>34.0</td>
</tr>
<tr>
<td>mean</td>
<td>22.8</td>
<td>58.69</td>
<td>36.05</td>
<td>76.90</td>
<td>46.95</td>
<td>79.87</td>
</tr>
<tr>
<td>S.D.</td>
<td>±7.01</td>
<td>±21.78</td>
<td>±13.40</td>
<td>±28.54</td>
<td>±18.50</td>
<td>±28.65</td>
</tr>
<tr>
<td>P</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.025</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
</tr>
</tbody>
</table>

The six main columns of figures correspond to the six fifteen minutes' collection periods. I.D.S. = iso-oncotic dextran-electrolyte solution, G.E.S. = glucose-electrolyte solution. Horizontal marks mean samples contaminated with blood. Statistical significance pertains to the difference between I.D.S. and G.E.S. in each collection period.
The mean concentrations of protein in the two types of irrigation fluid are shown in Figure 2. It may be seen that in the samples of I.D.S. they were consistently lower, representing 38.8, 46.6, 58.8, 70.0, 65.7 and 63.3% of the corresponding G.E.S. values. In the first three observation periods these differences were statistically significant. The detailed data are presented in Table II.

DISCUSSION

Our results show that dextran added to irrigation fluid in iso-oncotic concentration is fully effective in keeping the intra-peritoneal fluid volume constant and that the addition of glucose is not necessary to prevent an undesired reabsorption of fluid from the peritoneal cavity. The intra-peritoneal volumes did not change in the course of the whole 90 minutes’ observation period, which is more than sufficient since equilibration periods applied in clinical cases are usually of shorter duration. Although experiments with hyper-oncotic dextran concentrations were not performed in the present series, it may be expected that ultrafiltration might be achieved as well.

Protein concentrations in the dextran-containing fluid samples collected in the course of the first 45 minutes of the equilibration period were definitely lower than in those containing glucose. As the lower protein concentrations in the former could not be explained by a dilution — on the contrary it was the glucose-electrolyte fluid which showed a tendency to be diluted—it is assumed that it was due to a decreased protein diffusion rate across the peritoneal membrane. Such an interpretation seems to be valid even though both parameters were not studied in all animals at the same time. The fact that in several animals (pairs No. 1, 7, 8, Table II) not all successive samples were contaminated with blood suggests the importance of local irritation by the catheter during drainage. Such a contamination occurred especially in samples where suction had to be applied during collection. The same seems to apply to protein concentration—in several pairs of animals not included in the present series, in which short needles were used for both administration and evacuation of the rinsing
fluid, the concentrations of protein in the collected samples were usually very low. This might explain variations in protein concentration from sample to sample and the occasional presence of proteins of very high molecular weights in clinical cases (Berlyne et al., 1964).

At present it is difficult to say whether our experimental data may find some direct application in clinical medicine. Dextran is far from being an ideal substance for this purpose, because of its possible effect on the mobilization of heparin by local stimulation, and effect on the kidney, especially in patients with oliguria (Wilkinson et al., 1965; Niall and Doyle, 1966); much more work is needed before this principle might be introduced into clinical practice. Fine et al. (1946) were probably the first and only authors who used a rinsing fluid containing 5% gelatin in continuous peritoneal dialysis in a patient with acute renal failure, but the use of colloid irrigation fluid has not found broader application. However, it seems worth trying, because the average decrease in protein concentration to 48.1% of the glucose-containing fluid values in the first 45 minutes found in our experiments would mean a decrease in protein loss to about one half. Besides, the control of intra-peritoneal fluid volume by colloid material would seem safer for the patient since it is most probably effective even in cases where a part of the administered fluid is sequesterated and excluded from the regular exchange. The significance for all methods of peritoneal dialysis including the continuous one is evident.

Summary

1. In experiments in dogs intra-peritoneal fluid volumes and protein concentrations in the rinsing fluid were studied using a glucose-electrolyte and an iso-osmotic dextran-electrolyte solution as irrigation fluids.

2. The volumes of the dextran-containing fluid were constant during the whole 90 minutes' observation period, and its protein concentrations during the first 45 minutes of the equilibration period were significantly lower than those in the glucose-containing fluid. It is suggested that colloid material in iso-osmotic concentration is fully effective to control the intra-peritoneal fluid volume and that its presence lessens the diffusion rate of protein across the peritoneal membrane.

3. The significance of colloid glucose-free irrigation fluids for clinical application is discussed.

REFERENCES


