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Changes of surface tension of dialysate depending on its composition in continuous ambulatory peritoneal dialysis

Surface phenomena resulting from interactions among molecules occur commonly in nature (1, 3, 8, 10). Surfactants, substances with surface activity, have a big influence on surface tension. They reduce surface tension when added to the solution, even in minimal concentration (4, 5, 6). The examples of these substances are: proteins, free fatty acids, esters. Surfactants have a tendency to accumulate in the surface layer, where they arrange their hydrophilic part toward liquid, and hydrophobic part in the direction of gas (4, 8, 10–13). The behaviour of surface tension of the dialysate is difficult to proper assessment, because of its complex composition. Dialysate is a mixture of organic and inorganic substances, both macro- and micromolecular (2, 5, 6, 7, 13). Surfactants present in the dialysate affect its surface properties. Among them are proteins, phospholipids and fatty acids (5, 6). Proteins have the greatest influence on a surface tension of biological liquids, reducing it even in minimal concentrations (5, 6). Glucose, fructose, fatty acids, phospholipids, triglycerides, micromolecular nonionic surfactants such as alcohols, acids, ethers have similar effect (1, 4, 6, 10). The surface tension is also affected by a pH of the solution which influences the secondary structure of proteins and changes their properties. In the literature there are no publications showing the behaviour of surface tension of the dialysate. It seems that changes of surface tension in different situations accompanying peritoneal dialysotherapy have a significant influence on dynamics of peritoneal transport and ultrafiltration. In 1986 Di Paolo et al. observed a considerable decrease in concentration of phospholipids in the dialysate during peritonitis. They suggested that this state may significantly decrease ultrafiltration during peritonitis, through influence on surface tension. However, they did not measure the surface tension of the dialysate directly (2).

The aim of our study was to assess changes of dialysate surface tension in non-complicated peritoneal dialysis, depending on time of presence of dialysate fluid in the abdomen and on the concentration of proteins, urea, creatinine, glucose and its changes.

MATERIAL AND METHODS

The study was performed on 39 dialysate samples obtained from 6 patients chronically treated with continuous ambulatory peritoneal dialysis (CAPD). During the study patients had no symptoms of peritonitis. The samples of dialysate were collected directly after finishing dialysis exchange. The dialysis fluid of different concentrations (15g/L, 23g/L, 42.5g/L) was used in exchanges. The dialysate stayed in abdominal cavity from 161 to 627 minutes. The surface tension of the dialysate was determined, using the Wilhelmy's method, by KSV Sigma 70 device (10 measurements for every sample). Simultaneously the concentrations of sodium, glucose, urea, creatinine, total proteins were measured in the dialysate. Dwell time was also calculated (from the end of inflow to the end of outflow). Sodium concentration was estimated in the autoanalyzer STKS coulter by ionselective electrode, urea by enzymatic method and creatinine and proteins – by colorimetric methods. The statistical analysis was performed by using the PSIPLOT computer program. Methods of analysis of single and multiple regression were used.

RESULTS

Table 1 shows the mean values of the studied parameters in 39 dialysate samples. The range shows that they were very different for all the studied parameters. The results of the multiple linear regression analysis of the influence of changes in dialysate protein, glucose, sodium, creatinine, urea concentrations on surface tension are shown

Table 1. Mean values of studied parameters in peritoneal dialysate

Parameter	Mean ± SD	Range
Surface tension mN/m	53.8± 2.5	42.7 –56.6
Protein g/dl	0.183± 0.23	0.1 – 1.5
Glucose mg/dl	729± 311	154-1570
Sodium mmol/l	125± 6.2	114-141
Creatinine mg/dl	7.6± 2.4	3.7-14.7
Urea mg/dl	100± 33	44 – 190
Dwell time (min)	347± 157	161 - 627

Table 2. Linear multiple repression. Surface tension and studied parameters. y – surface tension; F=14.4; r=0.702

Parameters	T	P
Protein	-6.71	<0.00001
Glucose	1.53	0.1360
Sodium	-0.26	0.7982
Creatinine	0.25	0.8030
Urea	2.12	0.0402

in Table 2. In the analysis of multiple regression we have found a significant negative influence on surface tension for protein concentration and a weak significant positive correlation with urea concentration in the dialysate. Surface tension was not significantly dependent on the concentration of glucose, sodium, creatinine in dialysate. Figure 1 shows the relationship which was assessed by the single regression analysis method between surface tension and dwell time ($r = -0.3447$, $p = 0.04$).

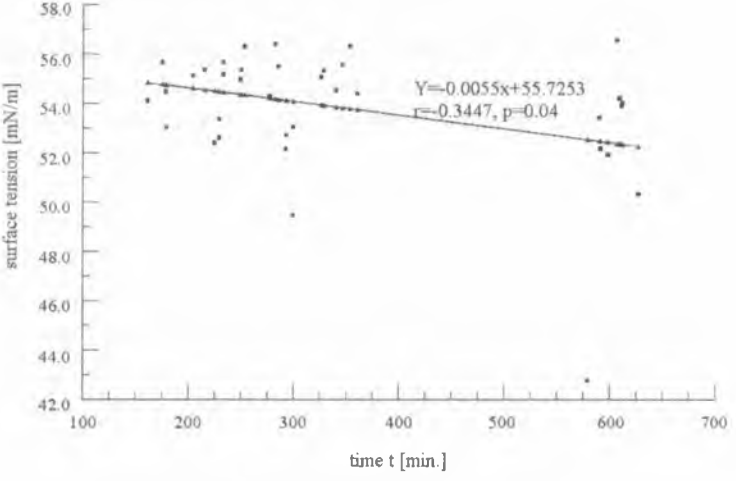

Fig. 1. Correlation between surface tension and dwell time

DISCUSSION

The extent of molecule transport between the blood and the dialysis fluid determines efficiency of peritoneal dialysis (7, 9). The transport of water molecules is particularly relevant from the clinical point of view because it directly determines the possibility of dehydration in dialyzed patients. There are several surfactants in the dialysate which influence its surface tension. Unquestionably, different proteins removal during

dialysis exchange play such a role (2, 5, 6). It is not known in what way the changes of surface tension are able to modify water transport in patients on CAPD. It appears that the decrease in dialysate surface tension negatively influences overall removal of water (decreases net ultrafiltration). Because the dialysate is a mixture of organic and inorganic substances, and it is known that some of them can influence surface tension, in our study we tried to establish the association between the concentration of micromolecular substances such as sodium, urea, creatinine and glucose and surface tension. Our results show that there is no obvious relationship between their concentration and the changes in dialysate surface tension. We have determined, as was expected, a significant negative correlation between dialysate protein concentration and surface tension. In our study we have only determined the total protein, without fractionation. It is known that protein transport to the dialysate increases with dwell time (7, 9). This explains the observed significant negative correlation between surface tension and time of exchange. Our studies are preliminary. The analysis of the association between increased protein loss, ultrafiltration decrease and surface tension during peritonitis needs to be carried out and this will be the subject of further studies.

CONCLUSIONS

1. The concentration of dialysate protein has a significant influence on surface tension of the dialysate.
2. With the increase of protein loss, dialysate surface tension decreases.
3. No correlation was found between dialysate surface tension and concentrations of sodium, glucose, and creatinine in the dialysate.

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SUMMARY

Surface phenomena resulting from interactions among molecules occur commonly in nature. Surfactants, substances with surface activity, have a big influence on surface tension. They reduce surface tension when added to the solution, even in minimal concentration. The behaviour of surface tension of the dialysate is difficult to properly assess, because of its complex composition. Dialysate is a mixture of organic and inorganic substances, both macro- and micromolecular. Among them are proteins, phospholipids, fatty acids. In the literature there are no publications showing the behaviour of surface tension of the dialysate. The aim of the study was the assessment of changes of dialysate surface tension in non-complicated continuous peritoneal dialysis (CAPD), depending on time of the presence of dialysis fluid in the peritoneal cavity and on the concentration of different substances in it. The study was performed on 39 dialysate samples obtained from 6 patients chronically treated with continuous ambulatory peritoneal dialysis (CAPD). During the study patients had no symptoms of peritonitis. Surface tension of the dialysate was determined, using the Wilhelmy's method. Ten measurements were performed in every sample of the dialysate and the mean values and standard deviation were calculated. Simultaneously the concentrations of sodium, glucose, urea, creatinine, total protein were measured in the dialysate. As a

result of the study a significant negative correlation between dialysate protein concentration and surface tension was found. The significant negative correlation between surface tension and the dwell time was also found. There was no significant correlation between the value of surface tension of the dialysate and concentrations of glucose, urea, creatinine and sodium.

Zmiany napięcia powierzchniowego dializatu w zależności od jego składu w ciągłej ambulatoryjnej dializie otrzewnowej

Zjawiska powierzchniowe występują powszechnie w przyrodzie. Wynikają one z oddziaływań międzycząsteczkowych. W warstwie powierzchniowej powstaje fikcyjna siła działająca stycznie do niej, wzdłuż jej obwodu, nazywana napięciem powierzchniowym. Duży wpływ na napięcie powierzchniowe mają surfaktanty. Po dodaniu do roztworu, nawet w niewielkim stężeniu, obniżają one napięcie powierzchniowe. Przykładami takich substancji są m.in. białka, kwasy tłuszczowe, estry. Zachowanie się napięcia powierzchniowego dializatu, ze względu na jego złożony skład, jest trudniejsze do jednoznacznej oceny. Jest on mieszaniną związków organicznych i nieorganicznych, zarówno wielko- jak i drobnocząsteczkowych. Na jego własności powierzchniowe wpływają wszystkie zawarte w nim surfaktanty. Autorzy nie znaleźli w dostępnym piśmiennictwie doniesień przedstawiających zachowanie się napięcia powierzchniowego dializatu. Celem naszej pracy była ocena zachowania się napięcia powierzchniowego dializatu w zależności od okresu przebywania płynu dializacyjnego w jamie brzusznej i od stężenia w nim różnych substancji w przebiegu niepowikłanej ciągłej ambulatoryjnej dializy otrzewnowej (CADO). Badania wykonano w 39 próbkach dializatu uzyskanego od 6 chorych dializowanych przewlekle CADO. W czasie badań chorzy nie mieli żadnych cech dializacyjnego zapalenia otrzewnej. Metodą Płytki Wilhelmiego oznaczano w dializacie napięcie powierzchniowe, w każdej próbce dokonując 10 pomiarów, obliczono średnią i odchylenie standardowe. Równocześnie oznaczano w dializacie stężenia sodu, glukozy, mocznika, kreatyniny, całkowitego białka. W wyniku przeprowadzonych badań stwierdzono istnienie istotnej ujemnej zależności między stężeniem białka w dializacie a wielkością napięcia powierzchniowego. Stwierdzono również istotną ujemną zależność między wartością napięcia powierzchniowego a czasem trwania wymiany dializacyjnej. Nie wykazano istotnej zależności między wartością napięcia powierzchniowego dializatu a stężeniem zawartych w nim glukozy, kreatyniny, sodu.