EFFICIENCY OF A DIALYSATE REDUCTION SYSTEM IN WHICH HYDROGEN GAS IS DISSOLVED IN AN ACID CONCENTRATE

Shigeru Otsubo[1, 2], Takeshi Shibata[2], Kosaku Nitta[3]
[1]Department of Blood Purification, Sangenjaya Hospital, Tokyo, Japan
[2]Department of Blood Purification, Tohto Sangenjaya Clinic, Tokyo, Japan
[3]Department of Medicine, Kidney Center, Tokyo Women's Medical University, Tokyo, Japan

Introduction

Accumulating evidence indicates that oxidative stress (OS), which is caused by an imbalance between oxidants and antioxidants, is elevated in subjects with uremia; furthermore, enhanced OS appears to play a central role in the development of comorbidities, such as cardiovascular disease. In chronic hemodialysis patients, OS can be exacerbated by the dialysis procedure itself, bio-incompatibilities with the dialysis apparatus, or the loss of antioxidants during dialysis. Moreover, the oxidation reduction potential (ORP*), which is used to estimate OS, is much higher in dialysate than in human blood. Recently, the hydrogen molecule (H_2) has been shown to possess a unique biological capacity to act as an anti-oxidative and anti-inflammatory substance. Accumulating evidence indicates that H_2 administration ameliorates organ damage in various models of ischemia and inflammation. We have developed a dialysate reduction system in which hydrogen gas is dissolved in an acid concentrate; here, we evaluated the effects of this system.

*Oxidation-Reduction Potential, ORP

ORP indicates the water's relative state to receive or gain electrons. A solution with a higher (more positive) ORP has the potential to oxidize a solution with a lower ORP.

Subjects and Methods

A total of 14 patients receiving maintenance hemodialysis were enrolled in this study. The system for dissolving hydrogen gas in an acid concentrate is shown in Figure. We performed hemodialysis using this system for 4 weeks. We estimated the change in the ORP (for both the dialysate and blood), the blood cell count, and the biochemistry data. We also estimated the change in fatigue after hemodialysis using a visual analog scale (VAS: 0 [none] to 10 [maximum]).

Results

The mean patient age was 61.9 ± 13.9 years, and the mean duration of hemodialysis therapy was 9.6 ± 9.2 years. All the patients underwent hemodialysis 3 times a week. The mean hemodialysis time was 3.9 ± 0.4 hours, and the mean blood flow was 244 ± 45 mL/min. The quantity of dialysate was 500 mL/min, and High-performance membranes were used for all the patients. The ORP of the dialysate by this dialysis system was 174 ± 70 mV lower than that of the conventional dialysis system. In the conventional dialysis system, the ORP of the blood rises 68 ± 31 mV at the exit of the dialyzer than the entrance, whereas the use of this reduction device suppressed the increase to 29 ± 21 mV (P=0.012). The blood cell count did not change significantly. For the biochemistry data, the ferritin level decreased from 91.9 ± 77.0 ng/mL to 63.0 ± 46.7 (P = 0.035), while all other investigated parameters did not show any significant changes. The VAS score for fatigue after hemodialysis also decreased from 2.9 ± 2.7 to 2.0 ± 2.5 (P = 0.015).

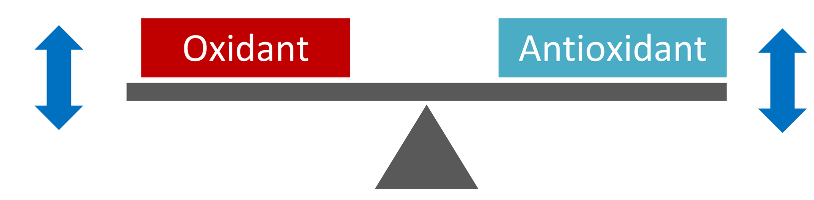
Oxidant/Antioxidant Balance

Oxidant

Reactive oxygen species
O_2^-
HO・
H_2O_2
$^1O_2$

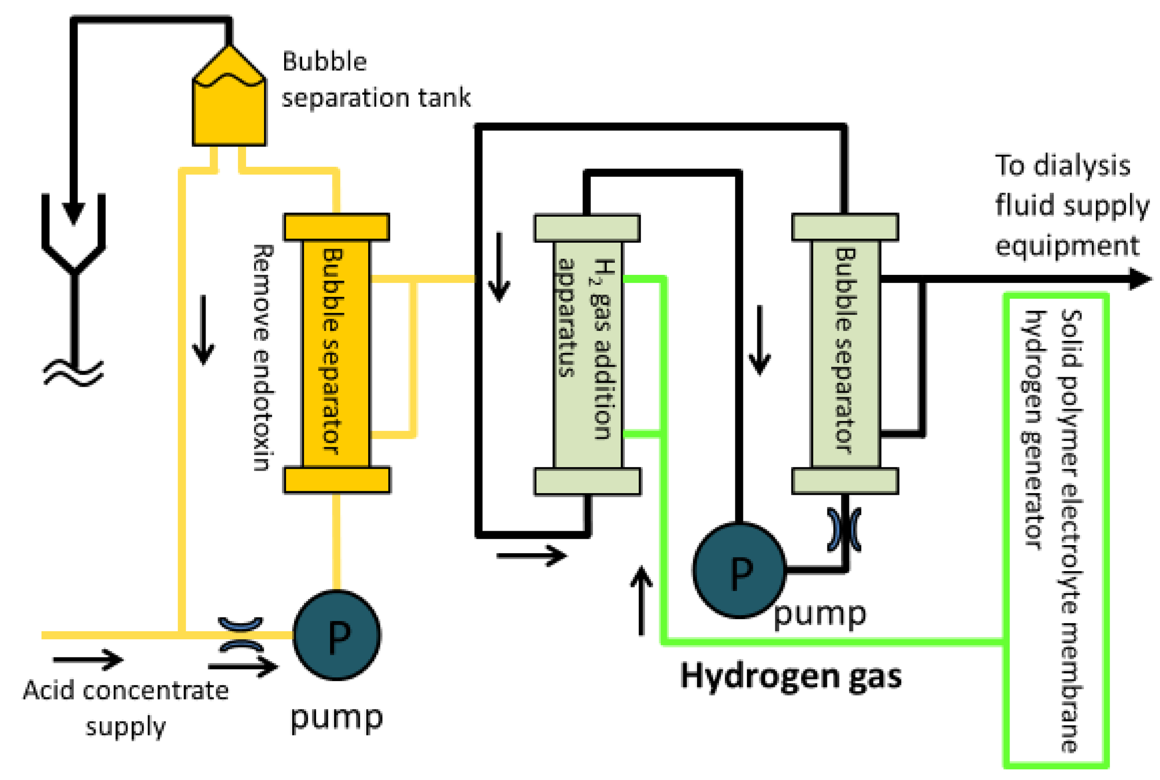
Antioxidant

Glutathione peroxidase
Superoxide dismutase
Catalase
peroxidase
Vitamin E/C
uric acid etc..



$H_2+2OH \rightarrow 2H_2O$

System for dissolving hydrogen gas to acid concentrate



Background characteristics of the study participants

	Quantity
Gender (M/F)	11 / 3
Age (year)	61.9 ± 13.9
Duration of HD (year)	9.6 ± 9.2
Primary Cause of ESKD, n	
Chronic glomerulonephritis	6
Diabetic Nephropathy	4
Nephrosclerosis	2
Unknown and others	2

HD: hemodialysis
ESKD: end stage kidney disease

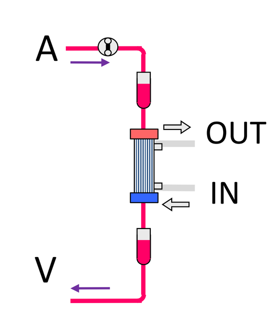
Hemodialysis data

	Quantity
Treatment time (hr)	3.9 ± 0.4
Quantity of blood flow (ml/min)	244 ± 45
Dialyzer	
NV-13S	2
NV-15S	1
APS-18SA	2
APS-21SA	7
PN-220S	2

Change of ORP

Change of ORP	Conventional system	Dialysate reduction system	P value
Blood (mV)	+68 ± 31	+29 ± 21	0.012
Dialysate (mV)	-126 ± 35	-74 ± 31	<0.0001

Change of ORP
Blood: V-A
Dialysate: OUT-IN



Change of blood cells

Blood cells	Pre	Post (4w)	P value
White blood cell (/µL)	6050 ± 1957	5964 ± 1615	NS
Hemoglobin (g/dL)	10.7 ± 1.0	10.9 ± 0.8	NS
Platelet (x10^4/µL)	17.8 ± 5.5	19.5 ± 7.9	NS

Change of visual analog scale

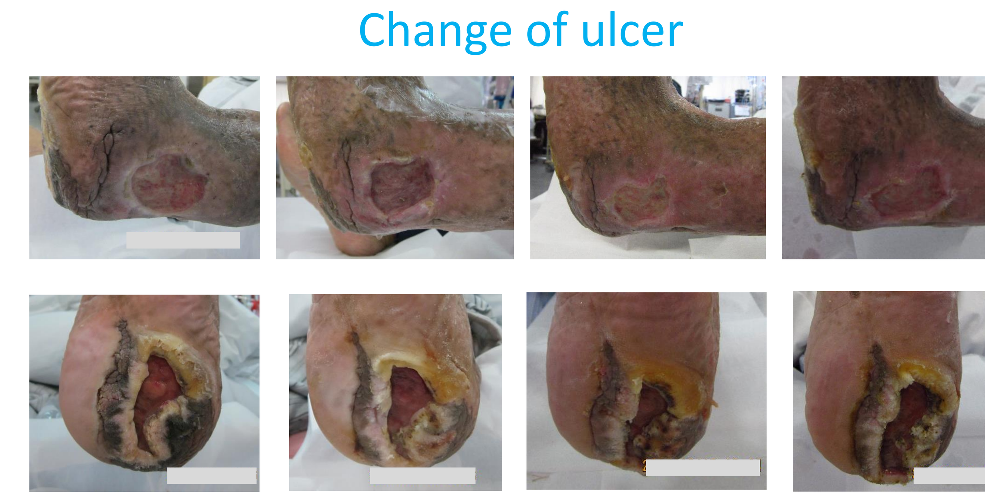
Visual analog scale	Pre	Post (4w)	P value
Fatigue	2.9 ± 2.7	2.0 ± 2.5	0.015

visual analog scale (VAS: 0 [none] to 10 [maximum]).

Change of Biochemistry

	Pre	Post (4w)	P value
Albumin (g/dL)	4.0 ± 0.2	4.0 ± 0.2	NS
Total bilirubin (mg/dL)	0.3 ± 0.1	0.3 ± 0.1	NS
Asparate aminotransferase (IU/L)	11.0 ± 3.4	11.1 ± 4.3	NS
Lactate dehydrogenase (IU/L)	173 ± 20	175 ± 31	NS
Urea nitrogen (mg/dL)	63.8 ± 17.1	67.5 ± 13.6	NS
Creatinine (mg/dL)	11.0 ± 2.5	18.3 ± 27.4	NS
Uric acid (mg/dL)	7.7 ± 1.4	7.8 ± 11.7	NS
Sodium (mEq/L)	139 ± 4	140 ± 3	NS
Potassium (mEq/L)	4.7 ± 0.5	4.8 ± 0.6	NS
Chlorine (mEq/L)	100 ± 4	101 ± 4	NS
LDL-cholesterol (mg/dL)	78 ± 26	78 ± 25	NS
MDA-LDL (IU/L)	77 ± 30	78 ± 20	NS
MDA-LDL / LDL	1.0 ± 0.3	1.0 ± 0.2	NS
Calcium (mg/dL)	8.7 ± 0.6	8.8 ± 0.5	NS
Phosphate (mg/dL)	5.2 ± 1.0	5.6 ± 1.2	NS
Iron (mg/dL)	54 ± 25	57 ± 21	NS
Total iron-binding capacity (mg/dL)	254 ± 34	269 ± 33	NS
Ferritin (ng/mL)	91.9 ± 77.0	63.0 ± 46.7	0.035
Transferrin saturation (%)	21.0 ± 9.3	21.9 ± 9.1	NS
c-reactive protein (mg/dL)	0.83 ± 1.9	0.26 ± 0.4	NS

Case
Change of ulcer



10M before | Strat of Dialysate reduction system | 3M after treatment | 4M after the stop of dialysate reduction system

Hemodialysis using Conventional system | 3M hemodialysis using dialysate reduction system | Hemodialysis using Conventional system

Conclusion

A dialysate reduction system in which hydrogen gas is dissolved in an acid concentrate enabled a reduction in the ORP of the dialysate. In dialysis treatment using this device, a significant decrease in ORP of blood was also observed. The ferritin level, which is an indicator of chronic inflammation, and the VAS score for fatigue were also reduced. This system might be useful for reducing OS in hemodialysis patients.

DOI: 10.3252/pso.eu.54ERA.2017