Bright Lights 294

Methanol Intoxication

Comparison of Peritoneal Dialysis and Hemodialysis Treatment

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A unique opportunity presented itself for reviewing and comparing the results of two different methods of dialytic therapy for the treatment of methanol (methyl alcohol) poisoning. The group that was treated with hemodialysis initially had a faster fall in serum methanol level, regained consciousness faster, had a shorter hospital stay, and, most importantly, had no residual effects when compared with the group treated with peritoneal dialysis. In this group, one patient died and another was permanently blinded. Therefore, we believe that hemodialysis, when available, is the initial treatment of choice in methanol poisoning and should be used concomitantly with alkaline therapy and the administration of alcohol (ethanol, ethyl alcohol).

Methanol (methyl alcohol) is a toxic agent that is widely available because of its various uses in industry. It is also used illicitly to adulterate alcohol (ethanol, ethyl alcohol). Despite all the warnings against its consumption, methanol poisoning is still seen periodically in small epidemic outbreaks.

Usually there is a latent period of 24 hours between ingestion of methanol and the development of toxic symptoms. Severity of poisoning generally has little relationship to the length of the latent period.[1] Patients may complain of nausea, vomiting, headache, vertigo, blurring of vision, diarrhea, and abdominal pain. The more serious presenting complaints are stupor, coma, convulsions, and blindness.[2]

Methanol poisoning is due to a combination of central nervous system depression, metabolic acidosis due to production of formic acid and other organic acids, and specific toxicity of the oxidation products of methanol for retinal cells that produce irreversible changes.[3] Methanol is primarily metabolized slowly in the liver by alcohol dehydrogenase to formic acid probably through formaldehyde.[3] Only 3% to 5% of ingested methanol is excreted unchanged through the kidneys.[4,5]

The standard forms of therapy include alkaline therapy to combat the severe acidosis[6] and alcohol administration, which has a competitive inhibitory action on oxidation of methanol.[7] Consequently, its administration in methanol poisoning can be used for the purpose of postponing the formation of the more toxic agents, formaldehyde and formic acid, which are respectively 33 and 6 times more toxic than methanol.[1]

Marc-Aurele and Schreiner[8] demonstrated that both methanol and alcohol fulfill the criteria for dialyzable poisons. Since methanol, with its toxic metabolic products, can cause serious irreversible complications such as blindness, there is an important rationale for removing methanol from the blood as fast as possible, namely with dialysis.

Recently, a small outbreak of methanol poisoning involved a group of six patients. They afforded an opportunity for almost a controlled study comparing two different dialytic treatment methods for methanol poisoning since the time of exposure to methanol occurred at the same time for all six, and all six received similar treatment except for the types of dialysis employed. Three patients treated at one hospital initially underwent hemodialysis. The other three patients treated at another hospital initially underwent peritoneal dialysis. The comparison of these two dialytic procedures in these two groups of methanol-poisoned patients forms the basis for this report.

Patient Summaries

A group of six previously healthy young adult printing shop workers were brought to emergency rooms of two different hospitals 24 hours after ingestion of an unknown amount of a printing solution that contained 60% methanol by volume. Three of these patients (group 1) were treated in hospital 1 with recycling single pair twin-coil hemodialyzer with a surface area of 1 sq m, and three were treated in hospital 2 with peritoneal dialysis (group 2). Peritoneal dialysis was done with the use of a standard, commercially available, 1.5% glucose dialysate with 2-liter exchanges on an hourly cycle. Methanol determination for both groups was done in the same laboratory using a gas chromatographic method that clearly distinguishes between methanol and alcohol.[9]

Group 1.—*Patient A.*—A 22-year-old white man was alert at the time of admission, but gradually became obtunded and unresponsive except to painful stimuli within two hours after admission. Initially, he was complaining of shortness of breath, blurring of vision and dizziness. His symptoms began 8 to 10 hours after the ingestion of methanol. Respiratory rate was 34 per minute, blood pressure was 140/70 mm Hg, and pulse rate was 86 beats per minute. Pupils were mildly dilated, but reactive to light. The fundi showed slight hyperemia of the disc. Serum methanol level was 185 mg/100 ml. The patient was treated with a total of 400 mEq of sodium bicarbonate intravenously during the first four hours, and 1,000 ml of 5% alcohol intravenously over an eight-hour period.

Three hours after admission he underwent hemodialysis for six hours. While undergoing hemodialysis he regained consciousness and continued to respond well.

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Methanol, Eye, Dialysis, Light-Flashes, Heart, Lungs, Work

He received another 2 liters of 5% alcohol during the rest of his course. The serum methanol level dropped from 185 mg/100 ml to zero at the end of dialysis.

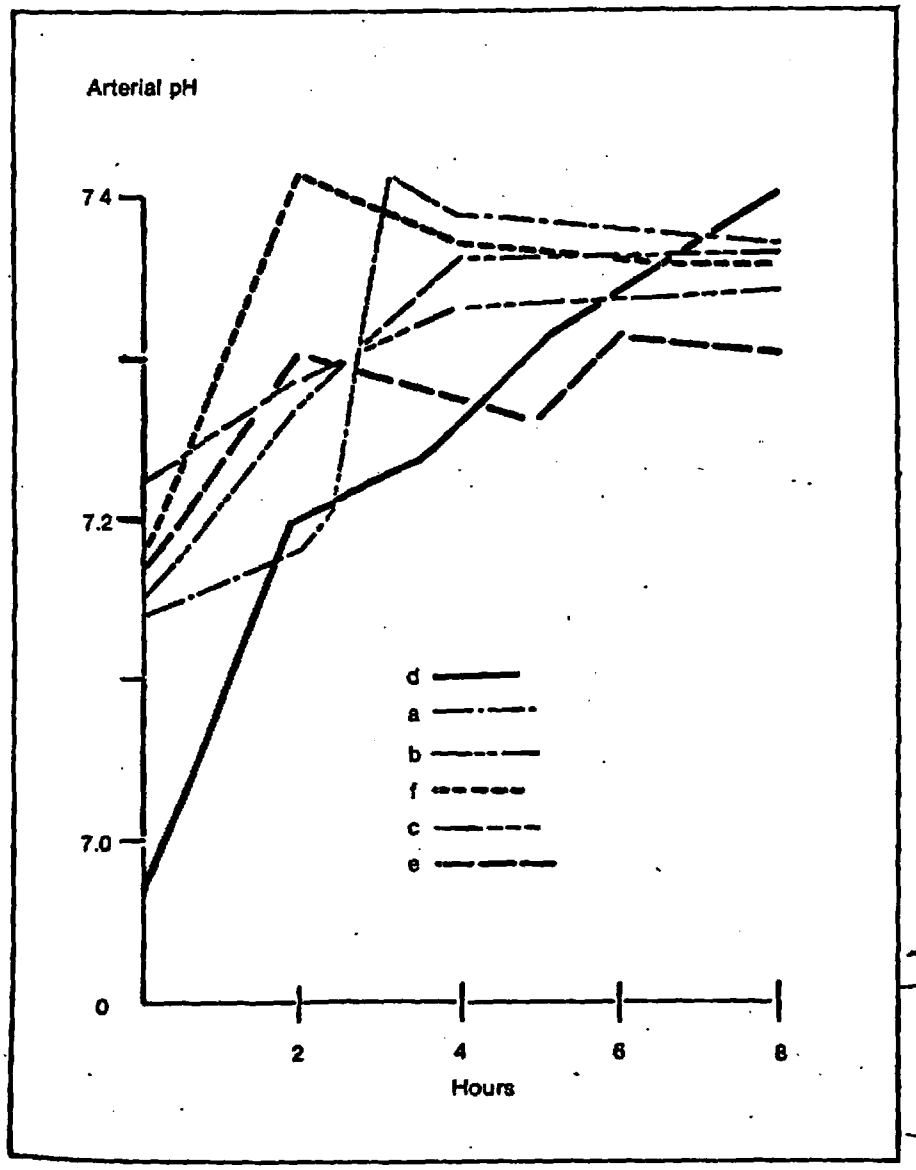
Three days after admission he had no complaints and was discharged.

Patient B.—A 21-year-old black man was admitted complaining of dizziness, headache, nausea, vomiting, and seeing bright lights before his eyes. The blood pressure was 120/80 mm Hg, with a pulse rate of 96 beats per minute and respiratory rate of 24 per minute. Fundi were normal. He had an S4 gallop. The remainder of the physical examination was normal. The serum methanol level was 178 mg/100 ml.

The patient received 275 mEq of sodium bicarbonate during four hours, and 60 ml of 95% alcohol orally, followed by 10 ml/hr orally for two days. Three hours after admission he underwent hemodialysis for four hours. He had no complaints and his vision was normal. The serum methanol level after four hours of hemodialysis was 54 mg/100 ml.

Patient C.—An 18-year-old Puerto Rican man was admitted with symptoms of nausea and vomiting. The blood pressure was 140/70 mm Hg, with a pulse rate of 90 beats per minute and respiration rate of 16 per minute. He had normal fundi, but cardiac examination revealed both S3 and S4 gallops. The serum methanol level was 96 mg/100 ml. The patient received 275 mEq of sodium bicarbonate during the first five hours, and was given 75 ml of 95% alcohol orally, followed by 10 ml/hr for two days. Four hours after admission, a four-hour hemodialysis was started. Because of hypotension and poor flow rates during dialysis, the procedure was relatively inefficient. The serum methanol level fell only to a level of 78 mg/100 ml by the end of dialysis. He did well, however, and was discharged after three days with no complaints.

Fig 1—Changes in arterial blood pH during first eight hours of therapy indicating major corrective change during first two hours of therapy prior to instituting dialysis (patients A to F).



Group 2.—*Patient D.*—A 23-year-old white man was in a confused state on admission, with a respiratory rate of 8 per minute, 20 hours after ingestion of the methanol-containing fluid. He was intubated in a nearby hospital and had a gastric lavage with sodium bicarbonate. Therapy with intravenously administered alcohol was begun. He was then transferred to hospital 2.

When he was seen in hospital 2 the patient was comatose, with a blood pressure of 80/40 mm Hg. Pupils were equal but unreactive to light. A respirator was required for adequate ventilation.

He received 400 mEq of sodium bicarbonate during the first three hours, followed by 5% sodium bicarbonate intravenously during the next three hours. Serum methanol level was 186 mg/100 ml. He also initially received 120 ml of 85% alcohol via a nasogastric tube, followed by 10 ml/hr for three days.

Four hours after admission, peritoneal dialysis was begun. As there was no marked improvement after 11 hours and the serum methanol level was still high at 130 mg/100 ml, the patient underwent hemodialysis for six hours with a hollow filter artificial kidney with surface area of 1 sq m. He also had a gastric lavage with 5% sodium bicarbonate twice a day. The patient remained unresponsive. On the second hospital day, a tracheostomy was performed. Levarterenol bitartrate (Levophed) was required for a short while to maintain his blood pressure. The course was then complicated by pneumonia and anuria. The patient died on the seventh hospital day.

Patient E.—A 28-year-old white man was brought to the emergency room unresponsive, with a blood pressure of 130/80 mm Hg, pulse rate of 88 per minute, and respiration rate of 28 per minute. Pupils were unreactive and mildly dilated. The fundi showed slight hyperemia of the disc.

The remainder of the physical examination was within normal limits. The serum methanol level was 198 mg/100 ml.

He received 165 mEq of sodium bicarbonate intravenously during the first 90 minutes. He also received 120 ml of 85% alcohol via a nasogastric tube, followed by 10 ml/hr for two days.

He was dialyzed peritoneally for ten hours beginning four hours after admission. At the end of peritoneal dialysis, the serum methanol level was still 161 mg/100 ml. He then underwent hemodialysis with a hollow filter artificial kidney with surface area of 1 sq m for five hours because of the lack of clinical improvement with peritoneal dialysis.

After four hours of hemodialysis, the patient regained consciousness at the same time that his pupils became reactive to light. He was discharged without any residual effects.

Patient F.—A 25-year-old white man was alert but had nausea, vomiting, dizziness, blurred vision, and deep and slow respiration with bradycardia on admission. Serum methanol level was 171 mg/100 ml. The patient received 275 mEq of sodium bicarbonate intravenously during the first two hours, and 120 ml of 85% alcohol by mouth initially. This was followed by 10 ml of alcohol per hour orally for two days. He had a gastric lavage with 5% sodium bicarbonate twice a day.

Four hours after admission, the patient was treated with peritoneal dialysis for ten hours. At the end of peritoneal dialysis, the serum methanol level was still 125 mg/100 ml. Due to a lack of clinical improvement, the therapy was changed to hemodialysis for 5½ hours using a hollow filter artificial kidney.

On the second hospital day, although alert, he had decreasing vision and could only see shadows. Funduscopy revealed pale discs with indistinct nasal margins, arteriovenous ratio of 2:3, and maculae that were clear bilaterally. The patient's blindness was considered to be secondary to methanol poisoning. A regimen of 120 mg of prednisone daily was continued for three days. Then, due to lack of improvement in vision, the prednisone dosage was tapered and discontinued after eight days. The patient was discharged on the tenth hospital day, with no recovery of vision.

Comment

The pertinent clinical findings and laboratory values of the two groups of patients are compared on admission and after eight hours of therapy (Table 1). Both groups appear to show the same degree of involvement with respect to the pertinent clinical and laboratory findings on admission. It is important to note, however, the significant differences between the two groups at the end of eight hours of therapy. In group 1 there has been a reduction of 66% in the mean serum methanol level compared to only a 13% reduction in the level in group 2. The clinical improvement appears to correlate well with the early reduction in the serum methanol level rather than with any of the measurements that mainly reflect acid-base balance.

The degree of acidosis, though quickly and equally well corrected in both groups (Fig 1), appeared to have little effect on the clinical course in terms of length of coma and visual disturbances. Therapy with bicarbonate appeared to have more influence on hydrogen ion balance than either mode of dialytic therapy.

The overall influence of dialytic procedures on the serum methanol level is illustrated in Fig 2. The end result, in terms of lowering the serum methanol level, is the same in both groups. However, the speed with which this is done is far greater with hemodialysis than with peritoneal dialysis. This agrees with the results of Setter et al,[10] who demonstrated that

Table 1.—Admission Findings

Patient	SMAL* mg/100 ml	pH	HCO_3, mEq/liter	P_{CO_2}, mm Hg	Coma	Visual Disturbance
Group 1						
A	185	7.14	4.0	8	Semicoma	+
B	178	7.16	5.5	16	...	+
C	96	7.22	6.0	16	...	...
Mean	153	7.17	5.16	13.3		
Group 2						
D	186	6.96	5.5	27	+	?
E	198	7.15	5.5	16	+	?
F	171	7.16	13.0	21	...	+
Mean	185	7.09	5.66	18.6		
Eight Hours After Admission						
Group 1						
A	22	7.37	12.0	10.5	...	+
B	54	7.37	16.0	30.0	...	...
C	78	7.34	13.2	26.0	...	...
Mean	51	7.36	13.7	22.1		
Group 2						
D	158	7.47	18.0	30.5	+	?
E	177	7.30	12.5	26.5	+	?
F	147	7.33	14.0	28.0	...	+
Mean	161	7.36	14.8	28.3		

* SMAL, serum methyl alcohol level.

Table 2.—Treatment Summary of Patients from Groups 1 and 2

Patient	Hospitalization, Days	Sodium Bicarbonate, mEq	95% Alcohol, ml	Complications
Group 1				
A	4	400	150	...
B	3	275	350	...
C	3	275	350	...
Mean	3.3	317	283	
Group 2				
D	7	630	715	Death
E	6	220	450	...
F	10	275	500	Blind
Mean	7.7	375	555	

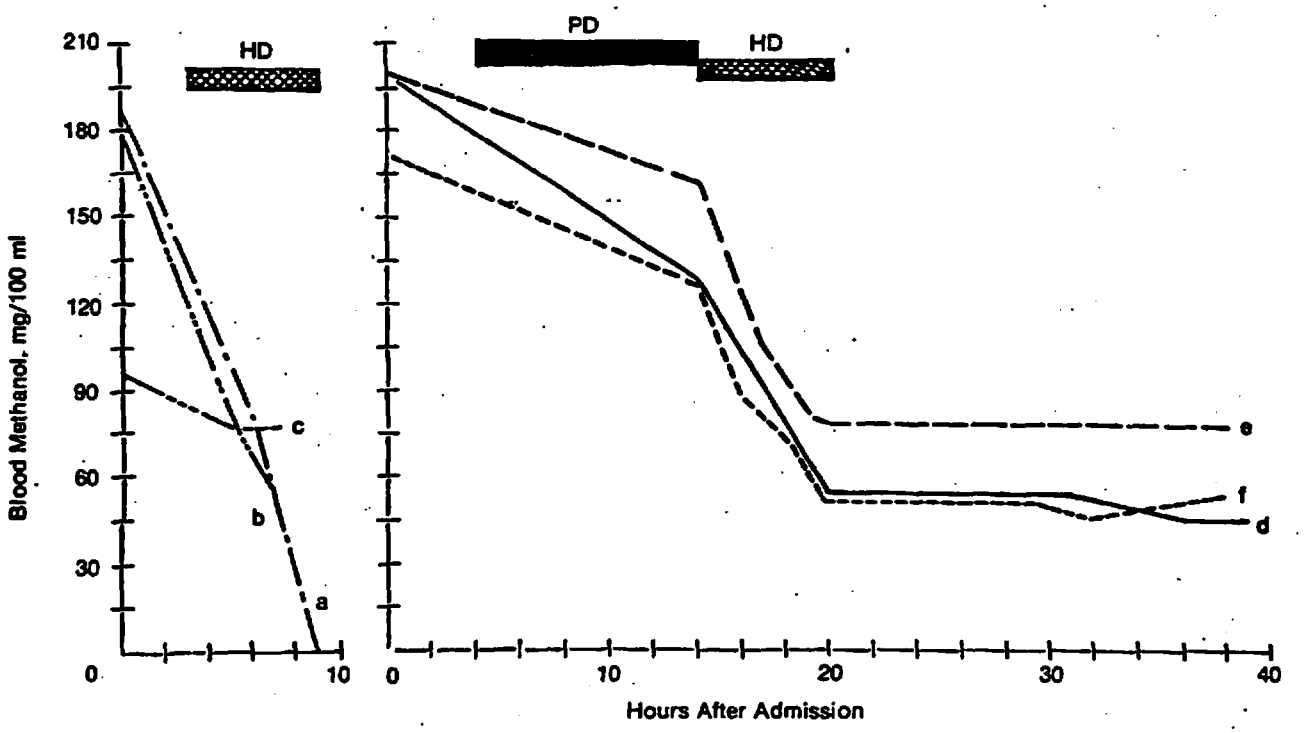


Fig 2.—Change in blood methanol level during periods of hemodialysis (HD) and peritoneal dialysis (PD) (patients A to F).

the clearance or dialysance of methanol in dogs is about eight times greater with hemodialysis using a twin coil than with peritoneal dialysis. These results do not match the results of peritoneal dialysis over an equivalent time span noted in a previous study by Stinebaugh.[11] The reason for this is unclear. However, in this latter study, no attempt was made by laboratory determinations to differentiate between alcohol (ethyl alcohol, ethanol) and methanol (methyl alcohol) blood levels—alcohol being readily metabolized, as compared to methanol, may account for the disparity in results. Although the group 2 patients received more alcohol than group 1 patients (Table 2), it has been shown that alcohol does not inhibit the dialysance of methanol.[8]

The rapidity of serum methanol reduction appears to be critical in terms of a good clinical outcome. Group 1, with hemodialysis initially, not only had a shorter hospital stay and required less bicarbonate and alcohol therapy, but, more importantly, had no serious complications when compared with group 2 where peritoneal dialysis was initially employed. The final clinical outcome in this group included one death and one case of permanent blindness (Table 2). It appears, therefore, that the severe permanent complications of methanol intoxication can be greatly minimized by prompt removal of methanol by hemodialysis.

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