NDT Plus (2008) 2: 89–91
doi: 10.1093/ndtplus/sfm016
Advance Access publication 4 January 2008

Case Report

NDT PLUS
Nephrology Dialysis Transplantation

Mechanical haemolysis related to the use of tandem dialyzers

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Keywords: Anaemia; dialysis; haemolysis

Introduction

Haemolysis is a well-recognized, rare complication of haemodialysis. The most common reasons for haemodialysis-associated haemolysis are chemical contamination, heat or mechanical injury of erythrocytes from occluded or partially occluded (kinked) haemodialysis lines [1–7].

Tandem dialyzers are occasionally used to improve dialysis dose, especially in patients with high muscle mass [8]. The two dialyzers are aligned in series and connected to each other by a simple blood line. Our patient had a partial occlusion (kink) at this blood line, which resulted in severe haemolysis. Since the changes in venous and arterial pressures were different from those noted with partial occlusion of the venous and arterial lines in standard haemodialysis, the problem was not immediately recognized. This case report describes a serious complication of tandem dialyzers that has not been previously reported.

Case

A 52-year-old male with end-stage renal disease and hypertension presented for his regular dialysis treatment. He was receiving three times weekly haemodialysis through a forearm arteriovenous fistula prescribed for 4 h and 15 min, with a blood flow of 400 mL/min and a dialysate flow of 800 mL/min. His dialysis included two dialyzers (Polyflux 210 H) in tandem because of high muscle mass.

At the beginning of treatment, the patient reported feeling well and had a blood pressure of 122/83 mmHg. After 1 h, the patient's blood pressure rose to 165/103 mmHg, and the dialysis machine alarm system was activated because venous pressure had dropped from 190 mmHg to 17 mmHg. Arterial pressure remained constant at −200 mmHg. The alarm was silenced and treatment resumed. Several minutes later, the dialysis machine alarm sounded, when venous pressure decreased to 11 mmHg. Arterial pressure was −140 mmHg. Again, the alarm was silenced and treatment resumed.

After ∼1 h of several cycles of resuming treatment after silencing the alarm for low venous pressures, the patient started to complain of substernal chest pain and shortness of breath; blood pressure was noted to be 198/110 mmHg. Haemodialysis was discontinued, and the patient was transferred to a hospital. On inspection of the dialysis equipment, it was noted that the tubing connecting the tandem dialyzers was kinked.

After arrival in the emergency department, the patient's plasma in blood samples obtained for laboratory testing were noted to be coffee-coloured, and the following significant laboratory values were obtained: haemoglobin 8.9 g/dL, haematocrit 15% (1 week prior to this event haemoglobin and haematocrit were 11.4 g/dL and 34.3%, respectively), potassium 4.8 mmol/L, total bilirubin 17.9 mg/dL, unconjugated bilirubin 14.9 mg/dL, lactate dehydrogenase 16764 U/L, aspartate aminotransferase 732 U/L and alanine aminotransferase 34 U/L.

A working diagnosis of intravascular haemolysis secondary to mechanical trauma to red blood cells from kinked haemodialysis tubing was made, and the patient was hospitalized. He received two units of packed red blood cells for severe anaemia and intravenous nicardipine for blood pressure control. All symptoms resolved. His haemoglobin stabilized with no signs of further haemolysis. LDH, bilirubin, AST all gradually returned to normal. Potassium remained in the normal range throughout his hospital stay. Haemodialysis was performed during hospitalization without tandem dialyzers. The patient was later discharged and received haemodialysis in the outpatient dialysis facility with stable haemoglobin and haematocrit.

We subsequently performed a controlled *in vitro* dialysis experiment to evaluate the effect of partial occlusion of blood lines at various sites, using saline and tandem dialyzers (Figure 1). Partial occlusion of the arterial line before the blood pump (A) results in a rapid increase in negative arterial pressure and activation of the machine alarm when the pressure becomes more negative than 250 mmHg. The blood pump will immediately stop again, if restarted without correction of the partial occlusion. Partial occlusion of

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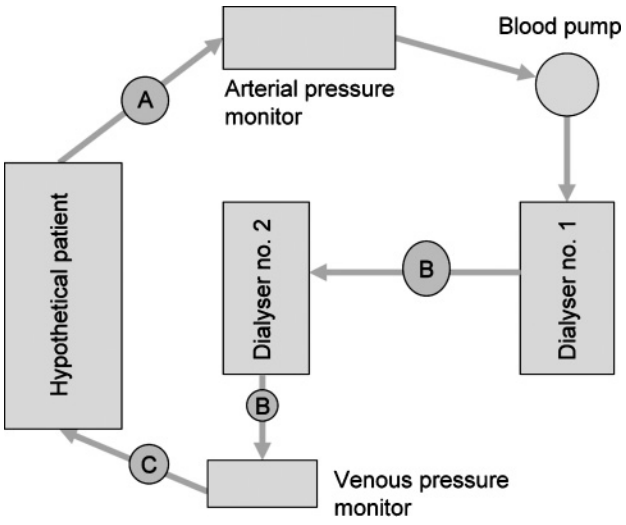

Fig. 1. Diagram of the *in vitro* dialysis experiment showing the location of partial occlusion of the blood lines. (A) Kinking of line proximal to the arterial pressure monitor causes immediate increase in negative pressure to below −250 mmHg. The machine alarms and cannot be overridden without correction of the kink. (B) Kinking of the tubing between the blood pump an the venous pressure monitor including the connecting segment between the two dialysers causes drop in positive venous pressure to approximately 15 mmHg indicating low blood return to patient. The machine alarms but can be overridden. (C) Kinking of the tubing distal to the venous pressure monitor causes immediate increase in venous pressure to above 250 mmHg. The machine alarms and cannot be overridden without correction of the kink.

the blood line connecting the two dialyzers (B) results in a slow decline in the venous pressure to ∼15 mmHg and reversal of the trans-membrane pressure. In this experiment, as in our patient's treatment, it was possible to restart the blood pump without correction of the partial occlusion. After silencing the alarm, a slow decline in venous pressure to between 10 and 20 mmHg again occurred, and only after several minutes (2–4 min depending on the severity of the occlusion) did the dialysis machine again activate the alarm. Similar results were obtained by partial occlusion of the blood line connecting the second dialyzer and the venous pressure monitor (B). Partial occlusion of the tubing returning blood to the patient (C) after the venous pressure monitor resulted in a rapid rise in venous pressure and activation of the alarm when the pressure exceeded 250 mmHg. The blood pump would immediately stop again if restarted without correction of the partial occlusion.

Haemolysis is a well-recognized but rare complication of haemodialysis. Haemolysis during haemodialysis results from contamination of the water system, excessive heat or erythrocyte damage caused by the shear injury from blood line occlusion or small-sized dialysis needles. Most patients with acute haemolysis during haemodialysis complain of back pain, chest tightness and shortness of breath [1–7]. A port-wine appearance of blood in the venous blood line, a pink discolouration of the plasma in centrifuged blood samples and a marked fall in haematocrit are usually noted. Dramatic deepening of skin pigmentation has also been described [9].

In routine haemodialysis, kinking of the blood tubing between the blood pump and dialyzer will not be detected, as the pre-pump arterial pressure monitor will not sense higher pressures encountered in this segment [10]. In tandem dialysis, blood traverses through two dialyzers connected in series by a blood line, before returning to the patient. This unique situation contains a connecting blood line which is normally not present in a routine haemodialysis treatment. It is this extra segment of tubing, distal to the blood pump but proximal to the venous pressure monitor, in which kinking will not be detected readily by the pressure monitors that present the increased risk of tandem dialysis. The venous pressure monitor detects lower positive pressures because of the decreased delivery of blood volume through the kink in the connecting segment.

In summary, we present a patient who was receiving haemodialysis through tandem dialyzers to achieve better clearance. He had a severe haemolytic reaction due to partial occlusion of the blood line between the two dialyzers. Nurses were able to repeatedly override the alarm and resume dialysis; consequently, the kink in the line was not immediately recognized. Our *in vitro* experiment, in which the alarm could be silenced and dialysis resumed, explains how it was possible for the dialysis treatment to be continued despite this partial occlusion. It is important for dialysis providers to visually inspect blood lines for occlusion, especially in areas in which the pressure monitors are less sensitive, such as the segment distal to the blood pump and proximal to the venous pressure monitor. Because of the extra segment of tubing in this area with tandem dialysis, extra caution is warranted. Low positive venous pressures are also a clue to the low blood return to the patient that occurs with kinking in this segment. Nurses, physicians and others involved in dialysis should be aware of this rare but life-threatening complication of the use of tandem dialyzers.

Conflict of interest statement. None declared.

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Received for publication: 31.10.07
Accepted in revised form: 6.11.07