Kidney International, Vol. 38 (1990), pp. 976–981

Regional citrate anticoagulation for continuous arteriovenous hemodialysis in critically ill patients

RAVINDRA L. MEHTA, BRIAN R. MCDONALD, MAY M. AGUILAR, and DAVID M. WARD

Department of Medicine, University of California, San Diego, San Diego, California, USA

Continuous arteriovenous hemodialysis (CAVHD) is being used increasingly as renal replacement therapy for critically ill patients with acute renal failure (ARF) [1–4]. Generally, the procedure has required systemic anticoagulation utilizing heparin or, in a few cases, prostacyclin to maintain filter patency [5]. Although heparin is removed by CAVHD membranes, systemic anticoagulation is usually unavoidable and has been associated with an increased incidence of bleeding [6]. In order to circumvent this problem, regional heparin anticoagulation has been tried [7], but this has not gained widespread acceptance due to the difficulty in accurately adjusting protamine doses. Similarly, CAVHD has been attempted with frequent saline flushes through the filter, but it has been difficult to keep the filter patent for longer than 24 hours [8].

We describe here a technique employing sodium citrate as a regional anticoagulant for CAVHD (citrate CAVHD). Citrate is an anticoagulant by virtue of its ability to chelate calcium. The anticoagulant effect is overwhelmed and neutralized when citrated blood from the extracorporeal circuit returns to and mixes with central venous blood. Citrate has been used for conventional hemodialysis [9–12], but not previously for CAVHD. In citrate CAVHD, trisodium citrate is infused at the origin of the extracorporeal circuit, but the low dialysate flow rate limits its removal across the membrane. To compensate for the metabolic consequences of the sodium citrate load, we have developed a special dialysate containing no alkali, subnormal sodium concentration and no calcium. Calcium homeostasis is restored by a separate calcium infusion.

In 2,000 hours of citrate CAVHD in eleven critically patients, this system has proved smooth, practical and effective, and has minimized the risks of hemorrhage and thrombocytopenia encountered with heparin use.

Methods

Patients

From December 1988 through July 1989, 18 patients with acute renal failure in the intensive care units at the University of California, San Diego (UCSD) Medical Center were treated with CAVHD; eight of them also received intermittent hemodialysis (IHD) (Table 1). Eleven patients received citrate CAVHD, eight underwent heparin CAVHD, and three had CAVHD using saline flushes for maintaining filter patency. We retrospectively reviewed their clinical course with respect to the method of anticoagulation used to maintain patency of the CAVHD filter.

Vascular access

Arterial access was through an 8 F, single lumen 6 or 8 inch silastic catheter (Medcomp catheter, Medcomp Corp., Harleyville, Pennsylvania; Vygon catheter, Renal systems, Minneapolis, Minnesota, USA) inserted into the femoral artery utilizing a Seldinger technique. Venous access utilized a double-lumen 14 or 16 F catheter (Vascath, Quinton Instruments, Seattle, Washington) inserted into the femoral or subclavian vein.

Filter

All patients were treated with a polyacrylonitrile membrane hemofilter in a parallel plate configuration with a surface area of 0.5 square meters (Hospal AN69S, Hospal-Gambro-Engstrom Inc., Lincolnshire, Illinois, USA).

Extracorporeal Circuit

Heparin CAVHD. A schematic of the circuit used is shown in Figure 1A. The filter was primed with two liters of heparinized saline containing 2500 U of heparin. Following an initial bolus of 5 to 10 U/kg, heparin was infused pre-filter at a rate of 3 to 12 U/kg/hr to maintain activated clotting times (ACT), (Hemochron 400, Kentec Inc., Irvine, California, USA), between 200 and 250 seconds post-filter. These determinations were made hourly with adjustment of the heparin infusion rate as frequently as needed to adhere to this range. Activated partial thromboplastin times (PTT) were checked peripherally one to two times per day.

Dialysate was Dianeal 1.5% (Baxter Corp., Deerfield, Illinois, USA) and dialysate flow rate was one liter/hr. The ultrafiltrate and effluent dialysate were collected in a urine bag, the height of which was adjusted to maintain an ultrafiltration rate of 400 to 600 ml/hr. Hourly measurements of ultrafiltrate were made and the desired net balance was achieved by replacing the excess removed with two replacement solutions given alternately. Solution A was one liter of 0.9% saline with 10 cc of 10% calcium gluconate, while Solution B was one liter of 0.45% saline with 50 cc of 7.5% sodium bicarbonate. Both replacement solutions were given pre-filter. Measurements of

Received for publication December 4, 1989
and in revised form May 15, 1990
Accepted for publication May 18, 1990

Published by Springer-Verlag, New York Inc.