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Treatment of Acute Renal Failure in Intensive Care Patients by Continuous Arteriovenous Hemofiltration (CAVH): Two Years' Experience in Two Centres

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ABSTRACT

The study objective was to evaluate the outcome of continuous arteriovenous hemofiltration (CAVH) as a first choice treatment for acute renal failure (ARF) in critically ill intensive care patients in two centres with a long experience in the field of continuous renal replacement therapies. Sixty consecutive intensive-care ARF patients from Uppsala Centre and 71 consecutive ARF patients from Vicenza Centre were included during a period of two years. Their age range was 58 ± 16 and 52 ± 15 years in Uppsala and Vicenza, respectively. CAVH was performed in the postdilution form using different types of hemofilters. Three choices of vascular access were utilised in each centre, namely: the Buselmeier shunt, femoral vessel catheter and the Scribner shunt.

The pre-treatment serum urea level (mean ± SD) in the Uppsala patients (30 ± 14 mmol/l) was significantly higher ($p<0.001$) than that of the Vicenza patients (17 ± 10 mmol/l). The Uppsala patients had a longer treatment duration than the Vicenza patients; 8 ± 6 vs 5 ± 5 days ($p<0.05$) perhaps because they were much older than the Vicenza patients ($p<0.05$) in addition to their multi-organ failure. However, the the total outcome of CAVH in the two centers was not significantly different (52 and 58% patient's survival in Uppsala and Vicenza, respectively).

The results from this study between two centres with a relatively high activity in the treatment of ARF in critically ill patients confirm previous results from smaller patient series that CAVH is an effective treatment in this type of patients if treatment starts early before the patient develops an advanced uremic state.

INTRODUCTION

Continuous arteriovenous hemofiltration (CAVH) was first utilised in acute renal failure treatment (ARF) and other medical problems like fluid overload due to congestive heart failure resistant to diuretics (11). Consequently CAVH has become an alternative to conventional hemodialysis (HD) for the treatment of complicated forms of ARF in the critically ill patients who need intensive care (10). CAVH is a simple extracorporeal treatment which utilises the patient's arteriovenous blood

pressure gradient to force the blood through a small filter with a semipermeable membrane. It can be used over an extended period of hours or weeks in which fluid, electrolytes, small and medium sized solutes are removed from the patient by ultrafiltration of which the rate is regulated by the level of filtrate-collection bag. In the majority of patients 12-15 litres of ultrafiltrate per 24 h are sufficient to obtain uremic control (5). However in hypercatabolic states (e.g. when serum urea level exceeds 30 mmol/l) even 20-40 litres per day would be needed in order to obtain such a goal. Blood volume must be readjusted by administration of a sterile fluid with an electrolyte composition similar to that of normal plasma (e.g. Ringer solution).

CAVH has been the main treatment for critically ill ARF patients in the Uppsala intensive care units since 1982. The purpose of this retrospective study was to evaluate the outcome of CAVH treatment from the long experience (more than 10 years) in two different centres (Uppsala Centre, Sweden and Vicenza Centre, Italy).

PATIENTS AND METHODS

Patients

A pooled data of sixty consecutive ARF intensive care patients (47 men, 13 women), age 58 ± 16 years, from the Uppsala Centre and 71 consecutive ARF patients (44 men, 27 women), age 52 ± 15 years, from the Vicenza Centre were included during a period of 2 years.

CAVH

All patients were treated with CAVH in the postdilution mode using different types of hemofilters in each centre (Table 1). Although some of the workers have utilised several techniques in attempt to improve the efficacy of CAVH by the addition of vacuum suction or pumps (6, 8, 12, 13), we preferred to perform only spontaneous CAVH in order not to interfere with the simplicity of this technique.

Table 1. Types of hemofilter membranes used in the Uppsala and the Vicenza Centres*

	Polysulfone hollow fibre				Polyacrylonitrile	Others
	AmD30	Am D20	Am D10	Renaflo HF250	Hospal 1200S	
Uppsala	82	9	2	7	-	-
Vicenza	24	31	1	-	26	18

AmD = Amicon diafilter
* values are given as a percentage of the total number of hemofilters which were utilised in each centre

In certain occasions, we performed instead continuous arteriovenous hemodialysis (CAVHD) (7) e.g. in patients in whom uremic control was difficult to control in spite of CAVH treatment. Prior to the introduction of CAVHD we used to perform additional sessions of intermittent hemofiltration in such patients.

Vascular access and anticoagulation

Femoral catheter was usually preferred when treatment was expected to be a short one, otherwise the Buselmeier and the Scribner shunts were preferred in Uppsala and Vicenza, respectively. Heparin was considered as the standard anticoagulant therapy in each centre in a bolus dose of 2000-4000 IU followed by an hourly i.v. dose of 10-15 IU/kg body weight. The dose was adjusted by following the activated partial thromboplastin time (APTT). Net ultrafiltration (UF) was usually adjusted to be more than 10 litres/day in order to achieve the goal of treatment in giving adequate uremic control.

Replacement and nutritional solutions

The choice of replacement solutions is dictated by the clinical condition of the patient (e.g. a potassium-free solution is recommended for patients with hyperkalemia). However, any sterile i.v. fluid with an electrolyte composition which is similar to that of plasma can be used e.g. Ringer's solution. This can also apply to the administration of nutritional fluids. It is an advantage that CAVH offers such opportunity even in anuric patients. Our example of nutritional management consists of amino acids (essential and non-essential) in 0.8-1.2 g/kg BW/day, carbohydrates 1000-3000 kcal/day (glucose in 30% solution with insulin is preferred especially in diabetic patients) and fat emulsions which are given as 500 ml Intralipid® (100 mg/ml) every second day in order to give 1000 kcal.

Indication for CAVH

In both centres CAVH was indicated for treatment of ARF alone or when complicated by multiple organ failure in critically ill intensive care patients in order to control azotemia and to facilitate administration of nutritional support.

Statistics

Comparison of the means was carried out by the Student's t-test.

RESULTS

Three types of vascular access were utilised in the Uppsala and the Vicenza Centres. These were Buselmeier shunt (88 and 3%), femoral vessel catheter (9 and 66%) and Scribner shunt (3 and 11%), respectively.

The major cause of ARF in the Uppsala centre(54%) was due to major surgery while that in Vicenza centre (48%) was due to a variety of medical problems (Tables 2, 3). This is because Uppsala is a big referral and University hospital and centre for cardiac surgery with a high turn over of bypass and valvular-correction operations.

Table 2. The medical causes of ARF in the two centres

ARF cause	Uppsala (n)	Vicenza (n)
MOF and/or septic shock	3	11
IHD	1	20
ARDS	-	3
Leptospirosis	-	3
Polycythemia	-	2
Acute pancreatitis	1	2
PD ultrafiltration loss	-	1
Pneumonia	-	1
Hepatorenal syndrome	3	4
Drug-induced	1	1
Rhabdomyolysis	1	-
Total	10	48

ARDS = acute respiratory distress syndrome, IHD = ischemic heart disease, MOF = multiple organ failure necessitating use of catecholamines and respirator, PD = peritoneal dialysis

Table 3. The surgical causes of ARF in the two centres

ARF cause	Uppsala (n)	Vicenza (n)
Abdominal surgery	3	5
Cardiac surgery	37	1
General surgery	3	8
Major burn	1	3
Major trauma	-	5
Resection of aneurysm of the abdominal aorta	6	1
Total	50	23

Table 4 shows that the Uppsala patients were older than the Vicenza patients ($p<0.05$) when age was considered as well as their mean (±SD) pre-treatment serum urea which was also significantly ($p<0.001$) higher than that of the Vicenza patients (30 ± 14 and 17 ± 10 mmol/l, respectively). The treatment duration was longer in the Uppsala patients ($p<0.05$). Heparin was administered in significantly higher doses ($p<0.01$) in the Uppsala Centre without any bleeding complications. The net 24 h UF volume did not differ much in both centres.

Table 4. Clinical data of Uppsala and Vicenza patients*

Parameter	Uppsala	Vicenza	Comparison
Age (years)	58 ± 16	51 ± 15	$p<0.05$
Systolic BP (mmHg)	106 ± 16	110 ± 23	ns
Serum urea (mmol/l) at start of CAVH	30 ± 14	17 ± 10	$p<0.001$
Serum urea (mmol/l) after beginning of polyurea	26 ± 10	18 ± 12	
Heparin dose (IU)/hr	675 ± 348	499 ± 229	$p<0.01$
Activated Partial Thromboplastin Time (APTT) (sec)	51 ± 17	39 ± 19	$p<0.001$
Ultrafiltration (UF) rate (l/24h)	14 ± 3	15 ± 6	ns
Treatment duration (days)	8 ± 6	5 ± 5	$p<0.05$

*values are given as means ± SD

Problems which were considered as complicating factors for ARF (Table 5) were almost similar in the two centres reflecting the severity of illness among these patients especially in the Uppsala Centre where 25% of the patients needed aortic balloon pump therapy in addition to vasopressor drugs. Another condition which might affected the outcome of CAVH in the Uppsala patients was the application of major vascular surgery in a relatively high number of patients in comparison to Vicenza patients.

Table 5. Factors complicating ARF in the two centres*

Complicating factor	Uppsala (n)	%	Vicenza (n)	%
Inotropic drugs	46	77	67	94
Mechanical respirator	31	52	29	41
Aortic balloon pump	14	25	0	-
Septicemia	2	3	11	16
Fungal infections	0	-	1	1

*values are given as a percentage of the total number of the patients in each centre

The outcome of CAVH was usually considered a patient's survival at the time when the patient leaves the intensive care unit to the general ward. Thus from the results of this study the total outcome of CAVH when compared in the two centres, did not show a significant difference (Table 6) where a patient survival of 52% and 58% was registered in the Uppsala and Vicenza Centres, respectively.

Table 6. The outcome of CAVH in the two centres

ARF cause	Uppsala			Vicenza		
	Patients (n)	Survivors (n)	Survival (%)	Patients (n)	Survivors (n)	Survival (%)
Post-surgical	50	27	54	23	15	65
Post-medical	10	4	40	48	26	54
Total	60	31	52	71	41	58

DISCUSSION

Management of ARF is a challenge especially when multiple organ failure is an additional problem (4). The present study describes an experience of two centres, one in Uppsala, Sweden, and another in Vicenza, Italy, where CAVH is used rather than HD for treatment of ARF in critically ill intensive care patients. This is because dialysis-related symptoms (e.g. arterial hypotension) which often complicates hemodialysis especially in the critically ill of whom the majority have unstable circulation, is not seen with CAVH. Our experience with peritoneal dialysis in ARF treatment was not encouraging in adult patients especially the hypercatabolic ones because of low ultrafiltration rate and abdominal problems like dialysis-fluid leakage. However, we found this to be useful in the critically ill children suffering from ARF in the intensive care unit (3).

In this study the outcome of CAVH treatment is similar in the two centres and also to a previous result in the Uppsala Centre (2). ARF was complicated by multiple organ failure in both centres. In addition to this the patients were of relatively old age specially in the Uppsala Centre, which we regard as a considerable risk factor for such a high mortality. In other reports old age (i.e. age >65 years) as well as the number and duration of system failures was found to play a great role of increasing hospital mortality among ARF patients (9). Therefore when standard hemodialysis was used in the past, it was found that one third of high risk ARF requiring intensive care management survived, and survival fell to one quarter in those requiring mechanical ventilation (14). Other risk factors to which the high mortality was related in the Uppsala Centre were the necessity to perform aortic balloon pump therapy on 25% of the Uppsala patients and surgery on the aneurysm of the abdominal aorta.

Regarding the type of vascular access used in each centre, the Buselmeier shunt comprised 82% of the total vascular accesses in the Uppsala Centre. By experience (1) it is found safe and does not restrict the patient to bed. It is also preferred in patients for whom a longer treatment duration is required. In the Vicenza Centre 66% of the vascular access used was of the femoral catheter type. This was preferred in the Uppsala Centre when the treatment duration is of a short duration.

Previously mentioned complications like bleeding due to disconnection of the tubings was not seen probably due to the present Luerlock system which has secured the extracorporeal blood lines from such accidental disconnection. However, filter clotting is still a problem complicating CAVH treatment. Frequency of filter change was in the range of 1-4 per patient in both centres. To avoid the lowering effect of fat emulsions on the ultrafiltration rate it is advisable to administer such solutions every other day.

In conclusion, CAVH is a simple and reliable method for the treatment of ARF in critically ill intensive care patients. From this experience a survival of about 50-60% can be expected in critically ill ARF patients if CAVH is started early. Being simple is an advantage as CAVH does not need any sort of complicated machinery like those usually seen in an intensive care unit.

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