

Impact of Extracorporeal Blood Flow on Blood Pressure, Pulse Rate and Cardiac Output in Hemodialysis Patients

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ABSTRACT

Background: If blood pressure (BP) falls during hemodialysis (HD) (intradialytic hypotension (IDH)) a common clinical practice is to reduce the extracorporeal blood flow rate (EBFR). Consequently, the efficacy of the HD (Kt/V) is reduced.

Aim of the Work: The aim of the present study is to investigate the impact of changes in extracorporeal blood flow rate (EBFR) on blood pressure (BP), pulse rate (PR) and cardiac output (COP) in hemodynamically stable patients during hemodialysis.

Patients and Methods: The population of this study consisted of 40 patients that on renal dialysis (RD) three sessions weekly. Patients were investigated prior to and after one conventional hemodialysis session. Prior to the hemodialysis session, an echocardiograph was performed to evaluate left ventricular ejection fraction (LVEF) and establish the degree of potential heart failure.

Result: In the present study regarding measure of BP, PR and COP in EBFR 200 ml/min, 300 ml/min and 400 ml/min, there was significant increase in systolic BP at an EBFR 200 ml/min as compared with EBFR 300 ml/min and EBFR 400 ml/min. but there was no significant change in systolic BP at an EBFR 300 ml/min as compared with an EBFR 400 ml/min.

Conclusion: IDH has been associated with many adverse clinical events including myocardial stunning, cerebral atrophy and increased mortality. Change of BFR from 400 ml/min or from 300 ml/min to EBFR 200 ml/min can increase in BP so help in decrease occurrence of complications of IDH beside other methods of increasing BP during hemodialysis.

Keywords: Blood flow rate, Blood Pressure, Intradialytic hypotension, Renal dialysis

INTRODUCTION

Symptomatic hypotension during hemodialysis (HD) (intradialytic hypotension (IDH)) occurs in 15–30% of hemodialysis sessions⁽¹⁾ and it is an independent predictor of cardiovascular morbidity⁽²⁾ and mortality⁽³⁾.

Intradialytic hypotensive events are a common complication of maintenance hemodialysis, affecting up to one third of chronic dialysis treatment sessions⁽⁴⁾. Intradialytic hypotension (IDH) can be defined as an abrupt decline in blood pressure that causes symptoms and/or requires an intervention⁽⁵⁾. Intradialytic hypotension has been associated with many adverse clinical events, including myocardial stunning⁽⁶⁾, cerebral atrophy⁽⁷⁾ and increased mortality⁽⁸⁾.

Predisposing factors include intrinsic patient-related factors such as the presence of autonomic neuropathy⁽⁹⁾, abnormal cardiac reserve⁽¹⁰⁾ and reduced venous compliance⁽¹¹⁾ as well as potentially modifiable treatment related parameters such as ultrafiltration (UF) profiling⁽¹²⁾ and changes in serum calcium concentration⁽¹³⁾.

The underlying pathophysiology of intradialytic hypotension seems to be multifactorial. Factors such as inadequate plasma volume during fluid removal⁽¹⁾, rapid reduction in plasma osmolality⁽¹⁴⁾, autonomic dysfunction⁽¹⁵⁾, heart disease⁽¹⁶⁾, impaired baroreflexes⁽¹⁷⁾, release

of endotoxins⁽¹⁸⁾, adenosine⁽¹⁹⁾ and increased synthesis of endogenous vasodilators have been suggest⁽²⁰⁾.

Intradialytic hypotension is usually treated by discontinuation of fluid removal and volume replacement⁽³⁾. Reduction in extracorporeal blood flow rate (EBFR) during hemodialysis has been suggested as a supplementary treatment modality⁽²¹⁾. However, data on the impact of changes in EBFR on blood pressure (BP) during HD are conflicting and very limited. Interestingly, data from⁽²²⁾ demonstrated that the SBP, DBP, and mean BPs were significantly higher during the BFR of 400 mL/min as compared with the blood flow of 200 mL/min, although data from⁽²³⁾ demonstrated a systolic BP was significantly higher at an EBFR of 200 mL/min as compared with 300 mL/min, but not as compared with 400 mL/min. At EBFR of 200, 300 and 400 mL/min diastolic BP, mean arterial pressure, PR and COP remained unchanged⁽²³⁾.

AIM OF THE STUDY

The aim of the present study is to investigate the impact of changes in extracorporeal blood flow rate (EBFR) on blood pressure (BP), pulse rate (PR) and cardiac output (COP) in hemodynamically stable patients during hemodialysis.

PATIENT AND METHODS

The population of this study consisted of 40 patients that on RD three session weekly. **The study was approved by the Ethics Board of Aswan University.**

Inclusion criteria:

- 1- Patients with an arteriovenous- fistula (AV- fistula) as vascular access.
- 2- Age of 18 years or above. Before study examination, the selected patients were not susceptible to symptomatic blood pressure decline during hemodialysis.

Exclusion criteria:

- 1- Pregnancy
- 2- Dementia.
- 3- Asymptomatic decline in systolic blood pressure below 100 mmHg or a symptomatic decline in systolic blood pressure equal to or above 30 mmHg during study examination.

Methods:

Patients were investigated prior to and after one conventional hemodialysis session. Prior to the hemodialysis session, an echocardiograph was performed to evaluate left ventricular ejection fraction (LVEF) and establish the degree of potential heart failure. Furthermore, AV fistula recirculation, a confounder of the measurement of EBFR was excluded at an EBFR of 400 mL/min. After the hemodialysis session with regular ultrafiltration (UF) of a maximum of 1 L/h for the patients to obtain dry weight, UF was stopped, while dialysis continued, to avoid any influence of fluid removal during the investigation. The patients were examined at EBFR of 200, 300 and 400 mL/min in random order.

Each EBFR was maintained for 15 min to gain steady state before measurements of BP, PR and COP. BP and PR were measured thrice and a mean was calculated while COP was measured twice and a mean was calculated. If there was a difference of >15% a third COP was measured and the mean of the two nearest results was used for calculation. Apart from the assessment of body weight (BW) all measurements were carried out with the patients in the supine position.

All hemodialysis sessions were according to the dialysis units standard with a temperature 37°C and dialysate ion-concentrations consisting of: NA^+ 140 mmol/L, HCO_3^- 38 mmol/L, K^+ 2 mmol/L, Ca^{2+} 1.25 mmol/L. Filters used were PF 170 or PF 210 from Gambro.

BP and PR were measured using the dialysis machine, while COP was measured using echocardiography.

Statistical Analysis

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean \pm standard deviation (SD). Qualitative data were expressed as frequency and percentage.

The following tests were done:

- When comparing between two means: Independent-samples t-test of significance was used.
- Chi-square (χ^2) test of significance was used in order to compare proportions between qualitative parameters.
- The dependability interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value considered significant as the following:
 - P-value <0.05 was considered significant.
 - P-value <0.001 was considered as highly significant.
 - P-value >0.05 was considered insignificant.

RESULTS

Table 1: Baseline patient characteristics and clinical data in study group

Parameter		N= 40 cases
Age (years) " mean \pm SD"		51.6 \pm 9
Male (n, %)		20 (50%)
Hypertension (n, %)		23 (58%)
DM (n, %)		13 (32%)
Previous IHD (n, %)		6 (15%)
Other diseases	Bronchial asthma	1 (2%)
	RHD	1 (2%)
	Thyrotoxicosis	1 (2%)
	SLE	2 (4%)

IHD: Ischemic heart disease, DM: Diabetes mellitus, SLE: systemic lupus erythematosus, RHD: Rheumatic heart disease, SD: standard deviation.

The Demographic data of the patients were illustrated in (Table 1). The study included 40 ESRD patients on regular dialysis.

Their ages ranged from 29 to 67 years with mean \pm SD = 51.6 \pm 9.20 patients (50%) of them were males and 20 were females (50%).

Among these patients there were 23 (58%) had hypertension, 13 (32%) had DM, 6 (15%) had IHD, 2 (4%) had SLE, 1(2%) bronchial asthma, 1(2%) had RHD and 1(2%) had thyrotoxicosis.

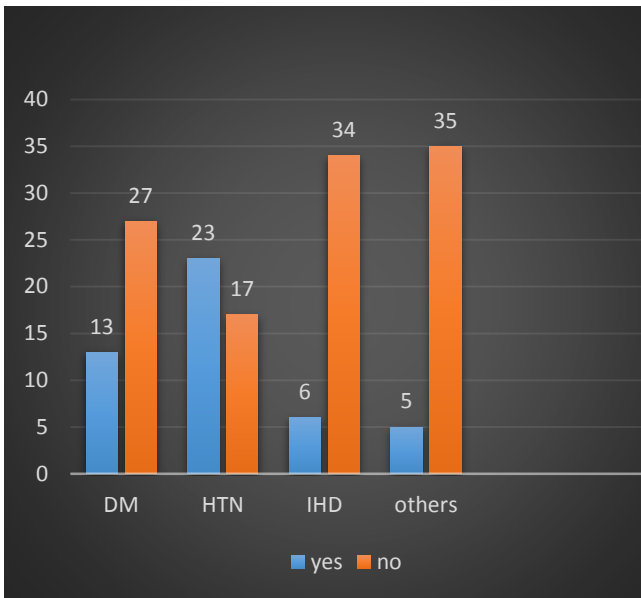


Fig. 1: Bar chart shows chronic diseases among patients in the study

Table 2: Blood pressure, pulse rate and cardiac output at extracorporeal blood flow rates 200 mL/min and extracorporeal blood flow rates 300 mL/min

Parameter Mean±SD	EBFR 200 mL/min	EBFR 300 mL/min	P value
SBP	130±14	127±14	< 0.05
DPB	65.7±9.1	65.6±9	0.16
Mean BP	84.7±9	84.7±9.4	0.2
Pulse rate	76.8±6.9	76.7±7	0.2
COP	4.9±0.7	4.92±0.6	0.5

EBFR: extracorporeal blood flow rate, SBP: systolic blood pressure, DBP: diastolic blood pressure, COP: Cardiac output, SD: standard deviation.

Table 2 shows that mean ± SD systolic blood pressure (130±14) at EBFR 200 mL/min was significantly higher (P value < 0.05) compared to mean ± SD systolic blood pressure (127±14) at EBFR 300 mL/min.

But the table shows that there was no significant change between EBFR 200 mL/min at (mean± SD diastolic blood pressure (65.7±9.1), mean ± SD mean BP (84.7±9), mean ± SD pulse rate (76.8±6.9) and EBFR 300 mL/min at (mean ± SD diastolic blood pressure (65.6±9), mean ± SD mean BP (84.7±9.4), mean ± SD pulse rate (76.7±7) and mean ± SD COP (4.92±.6)) respectively.

Table 3: Blood pressure, pulse rate and cardiac output at of extracorporeal blood flow rates 200 mL/min and extracorporeal blood flow rates 400 mL/min

Parameter	EBFR 200 mL/min	EBFR 400 mL/min	P value
SBP“ mean ± SD”	130±14	126±14	< 0.05
DPB“ mean ± SD”	65.7±9.1	65.5±9.1	0.1
Mean BP“ mean ± SD”	84.7±9	84.6±9	0.08
Pulse rate“ mean ± SD”	76.8±6.9	76.7±6.8	0.2
COP“ mean ± SD”	4.9±0.7	4.89±0.6	0.9

EBFR: extracorporeal blood flow rate, SBP: systolic blood pressure, DBP: diastolic blood pressure, COP: Cardiac output, SD: standard deviation.

Table 3 shows that mean ± SD systolic blood pressure (130±14) at EBFR 200 mL/min was significantly higher (P value < 0.05) compared to mean ± SD systolic blood pressure (126±14) at EBFR 400 mL/min. But the table shows that there was no significant change between EBFR 200 mL/min at (mean± SD diastolic blood pressure (65.7±9.1), mean ± SD mean BP (84.7±9), mean ± SD pulse rate (76.8±6.9) and mean ± SD COP (4.9±.7)) and EBFR 400 mL/min (mean ± SD diastolic blood pressure (65.5±91), mean ± SD mean BP (84.6±9), mean ± SD pulse rate (76.7±6.8) and mean ± SD COP (4.89±.6)) respectively.

Table 4: Blood pressure, pulse rate and cardiac output at of extracorporeal blood flow rates 300 mL/min and extracorporeal blood flow rates 400 mL/min.

Parameter	EBFR 300 mL/min	EBFR 400 mL/min	P value
SBP “ mean ± SD”	126±14	126±14	0.08
DPB“ mean ± SD”	65.6±9	65.5±9.1	0.5
Mean BP“ mean ± SD”	84.7±9.4	84.6±9	0.6
Pulse rate“ mean ± SD”	76.7±7	76.7±6.8	0.5
COP“ mean ± SD”	4.92±0.6	4.89±0.6	0.1

EBFR: extracorporeal blood flow rate, SBP: systolic blood pressure, DBP: diastolic blood pressure, COP: Cardiac output, SD: standard deviation

Table 4 show that there was no significant change between EBFR 300 mL/min (mean ± SD systolic blood pressure (126±14), mean ± SD diastolic blood pressure(65.6±9), mean ± SD mean

BP (84.7±9.4), mean ± SD pulse rate (76.7±7) and mean ± SD COP (4.92±.6) and EBFR 400 mL/min (mean ± SD systolic blood pressure (126±14), mean ± SD diastolic blood pressure (65.5±91), mean ± SD mean BP (84.6±9), mean ± SD pulse rate (76.7±6.8) and mean ± SD COP (4.89±.6) respectively.

DISCUSSION

The present study aimed to investigate the impact of changes in extracorporeal blood flow rate (EBFR) on blood pressure (BP), pulse rate (PR) and cardiac output (CO) in hemodynamically stable patients during hemodialysis. The population of this study consisted of 40 patients who were on regular HD 3 times weekly.

In the present study regarding measure of BP, PR and COP in EBFR 200 ml/min, 300 ml/min and 400 ml/min:

There was significant increase in systolic BP at an EBFR 200 ml/min as compared with EBFR 300 ml/min and EBFR 400 ml/min. but there was no significant change in systolic BP at an EBFR 300 ml/min as compared with an EBFR 400 ml/min.

At EBFR 200, 300, 400 ml/min; diastolic BP, mean arterial pressure (MAP), pulse rate (PR) and cardiac output (COP); there was no significant change.

These results are similar to the result of **Philip *et al.*** ⁽²³⁾ that there was increase in systolic BP at an EBFR 200 ml/min compared to EBFR 300 ml/min but in **Philip *et al.*** ⁽²³⁾ study there was no significant change between systolic BP in EBFR 400 ml/min compared to EBFR 200 ml/min.

Against our study; **Trivedi *et al.*** ⁽²²⁾ demonstrated an increase in SBP (4.1 mmHg) and DBP (3.0 mmHg) during an increase in EBFR from 200 to 400 mL/min.

A randomized study by **Alfurayh *et al.*** ⁽²⁴⁾ examined the effect of randomly chosen EBFR of 250 mL/min, 350 mL/min and 450 mL/min in 10 young, stable chronic HD patients free of antihypertensive treatment during three HD sessions a week apart. They found no changes in LVEF or CO, nor in PR or BP.

In a prospective, observational study of 218 prevalent HD patients **Flythe *et al.*** ⁽²⁵⁾ did not find any association between changes in EBFR and SBP variability (EBFR <400 ml/min versus ≥400 ml/min). In contrast, data from the HEMO study ⁽²⁶⁾ suggested a lower incidence of IDH with increasing EBFR.

Comparable to previous studies there are several limitations of the present study. None of the patients experienced any IDH during the investigation. Whether a reduction in EBFR during IDH will affect systemic BP is still not established.

All patients in the present study were examined at the end of a conventional dialysis. Previous data by **Bergström *et al.*** ⁽¹⁴⁾ have demonstrated that a rapid reduction in plasma osmolality (removal of urea and other solutes) initiated at the onset of HD contributes to IDH, due to osmotic removal of fluid into the cells depleting the extracellular volume and interference with sympathetic responsiveness to volume depletion (UF).

CONCLUSION

- 1-Intradialytic hypotension (IDH) is a common complication in a hemodialysis patients that affecting up to one third of chronic hemodialysis patients.
- 2-Intradialytic hypotension (IDH) is an independent predictor of cardiovascular morbidity and mortality.
- 3-Inradialytic hypotension (IDH) has been associated with many adverse clinical events including myocardial stunning, cerebral atrophy and increased mortality.
- 4-Change of EBFR from 400 ml/min or from 300 ml/min to EBFR 200 ml/min can increase the blood pressure (BP) so help in decreasing occurrence of complications of IDH beside other methods of increasing BP during hemodialysis (HD).
- 5-There is no significant relation between change of EBFR and diastolic BP, MAP and COP.

RECOMMENDATION

- 1-decrease in EBFR to 200 ml/min will help us in prevention of IDH.
- 2-Further studies are needed to evaluate the relation between EBFR and change in BP
- 3-Other studies needed to be done during HD without stopping UF.

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