Action of irbesartan on blood pressure and glucose/lipid metabolism, in hemodialysis patients with hypertension

Background: Irbesartan has been reported to have beneficial effects on glucose/lipid metabolism in addition to an antihypertensive effect; however, such effects have not been clarified in hemodialysis (HD) patients. We investigated the effects of irbesartan on blood pressure (BP) as well as glucose/lipid metabolism, in HD patients with hypertension.

Methods: Seventeen HD patients with hypertension, aged 62.7 ± 12.5 years, were treated with daily oral administration of 50 to 100 mg of irbesartan for 12 weeks. Then, the changes of BP as well as glucose metabolism (random serum glucose level and serum glycosylated hemoglobin [HbA1c] level) and lipid metabolism (serum low-density lipoprotein cholesterol [LDL-chol] level, serum high-density lipoprotein cholesterol [HDL-chol] level, and serum triglyceride [TG] level) were evaluated.

Results: Irbesartan significantly reduced systolic BP (154.9 ± 12.8 to 139.4 ± 13.1 mmHg (P, 0.01) and diastolic BP (78.9 ± 9.1 to 72.2 ± 9.7 mmHg, P, 0.01). It also reduced LDL-chol (77.6 ± 19.1 to 72.0 ± 18.6 mg/dL, P, 0.05), whereas it did not significantly affect random serum glucose (129.3 ± 46.9 mg/dL to 130.6 ± 47.2 mg/dL), HbA1c (5.58% ± 1.41% to 5.49% ± 1.11%), TG (104.3 ± 65.8 mg/dL to 100.2 ± 59.9 mg/dL), or HDL-chol (44.8 ± 17.1 mg/dL to 45.7 ± 15.6 mg/dL).

Conclusion: Irbesartan is effective for BP control and may have beneficial effects on lipid metabolism in HD patients.

Keywords: irbesartan, hemodialysis patients, blood pressure, glucose/lipid metabolism

Introduction

Hypertension is a major risk factor for the development of cardiovascular events and increases mortality in patients with end-stage renal disease undergoing hemodialysis (HD).1,2 Activation of the renin-angiotensin-aldosterone system (RAAS) plays a pivotal role in the pathogenesis of hypertension in HD patients,3–5 although volume overload is considered the most critical factor.3–8 Repeated clinical trials reported that RAAS blockers, such as angiotensin I-converting enzyme inhibitors (ACEIs) and angiotensin receptor blockers (ARBs), can reduce blood pressure (BP), cardiovascular events, and mortality in HD patients.4,5,9 These lines of evidence suggest that RAAS blockers would have beneficial effects in the treatment of hypertension in HD patients.4,5,9 Therefore, they are recognized as first-line drugs for the treatment of hypertensive HD patients.4,10,11

Glucose and lipid abnormalities have also been shown to increase the risk factors of arteriosclerosis, leading to the development of cardiovascular events in HD patients.6,7,12,13 A previous clinical study reported that high serum non-high-density
lipoprotein cholesterol non-(HDL-chol) level and serum low-density lipoprotein cholesterol (LDL-chol) level were associated with an increased risk of cardiovascular disease in HD patients.\textsuperscript{7} Hyperlipidemia leads to the accumulation and deposition of lipid in blood vessels and can act to trigger inflammation by stimulating the infiltration of macrophages, which in turn, secrete proinflammatory cytokines.\textsuperscript{14} Other clinical studies suggested that poor glycemic control was also associated with an increased risk of cardiovascular disease and high mortality in HD patients.\textsuperscript{15,16} Hyperglycemia has been reported to induce atherosclerosis through multiple mechanisms, for example, by producing advanced glycation end products, by increasing oxidative stress, and by activating protein kinase C.\textsuperscript{17} Therefore, appropriate control of glucose and lipid metabolism should be important to improve the survival of HD patients.

Irbesartan, an ARB, has been reported to reduce BP and cardiovascular events in hypertensive patients by blocking the effects of angiotensin II, which induces vasoconstriction and the secretion of aldosterone. Furthermore, it has also been reported to have beneficial effects on glucose/lipid metabolism, by acting as an agonist of peroxisome proliferator-activated receptor (PPAR)-\( \gamma \), in hypertensive patients with metabolic syndrome.\textsuperscript{18} A clinical study showed that the administration of irbesartan at 150 or 300 mg/day decreased fasting serum glucose, glycosylated hemoglobin (HbA\textsubscript{1c}), LDL-chol and triglyceride (TG) and increased HDL-chol in hypertensive patients.\textsuperscript{19} However, the effects of irbesartan on glucose/lipid metabolism have not been elucidated in HD patients. Therefore, in this study, we investigated the effects of irbesartan on glucose/lipid metabolism, along with its antihypertensive effects, in hypertensive HD patients.

Materials and methods
This study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of Jichi Medical University. Written, informed consent was obtained from all patients.

Patients
Seventeen HD patients with hypertension were enrolled in this study between February 2012 and May 2012. Patients were included if they were classified as hypertensive HD and were not being treated with ARBs. Patients were classified as hypertensive when the clinic BP was \( \geq 140 \) mmHg systolic and \( \geq 90 \) mmHg diastolic before an HD session on the last HD day of the week. The upper limits of BP were not set. Whether or not the patients had abnormal glucose/lipid metabolism was not considered for recruitment. The exclusion criteria were: patients who had already received ARB treatment; hyperkalemia (\( >5.5 \) mEq/mL) before the HD session; type 1 or type 2 diabetes mellitus with poor glucose control (serum HbA\textsubscript{1c} level \( >9\% \)); coronary heart disease; severe arrhythmia; cerebrovascular disease or any medical condition that may have affected the pharmacokinetics of the study drug; and pregnancy.

Study protocol
This was a 16-week, multicenter study consisting of a 4-week observation period, followed by a 12-week irbesartan treatment period (Figure 1). In the observation period, patients' dry weight and the doses of any drugs, including antihypertensives and medications taken for glucose and lipid metabolism, were not changed. Then, all enrolled patients entered the treatment period, during which they received irbesartan at 50 mg orally once daily in the morning, in addition to the drugs that they had been taking in the observation period. BP was measured before all HD sessions. If the BP had not decreased to less than 140/90 mmHg by 4 weeks after the administration of 50 mg of irbesartan, the treatment dose was increased to 100 mg/day, with careful attention to BP decrease during the HD (by ultrafiltration) sessions. If the BP did not decrease to less than 140/90 mmHg with the administration of 100 mg of irbesartan, the addition of another class of antihypertensive agent that the patient had not previously been taking would be considered.

Blood samples were obtained from an arteriovenous shunt at the start of the first HD session in a week, at the same time of day for each patient. The plasma renin activity, plasma aldosterone concentration, random serum glucose level, serum HbA\textsubscript{1c} level, serum total cholesterol level, serum TG level, serum HDL-chol level, and serum LDL-chol level were measured at baseline (week 0) and at week 12 in the treatment period, before the HD sessions. The standard laboratory tests were performed in the observation period and at baseline, week 4, and week 12 in the treatment period. All the blood parameters were measured by a commercial laboratory (SRL, Inc, Tokyo, Japan).

Statistical analysis
All data were expressed as the mean \( \pm \) standard deviation (SD). Comparisons of BP at weeks 0, 4, 8, and 12 were performed by one-way repeated measures analysis of variance (ANOVA). Comparisons of blood parameters were performed by paired \( t \)-test. Differences with a \( P \)-value \( <0.05 \) were considered to be statistically significant.
Results
Seventeen HD patients were enrolled in the treatment period after the 4-week observation period. All patients had oliguria or anuria. Among them, one patient dropped out of the study owing to symptomatic hypotension. This patient was a 70-year-old male who had been on HD for 6 years and 8 months. His initial nephropathy was chronic glomerulonephritis. He had not been taking other antihypertensives. His BP prior to the HD session had not decreased to less than 140/90 mmHg. Further antihypertensives of other classes were not added in any patients in the treatment period. Table 2 shows the clinical characteristics of the study patients before and after irbesartan treatment, including the changes of BP and the dosage of antihypertensives and the drugs for glucose/lipid control. Antihypertensives that had been taken by the study patients before the treatment period included calcium antagonists (eleven patients), ACEIs (two patients), direct renin inhibitor (one patient), α-blockers (four patients), and an αβ-blocker (one patient). Two patients had been taking statins (pravastatin 10 mg/day and atorvastatin 10 mg/day, respectively). Six patients had been diagnosed with diabetes mellitus and of these, two patients were treated with insulin and an α-glucosidase inhibitor, one patient was treated with an α-glucosidase inhibitor. Three patients were not treated with any drugs.

The effect of irbesartan on BP
Systolic BP significantly decreased from 154.9 ± 12.8 mmHg at baseline to 139.4 ± 13.1 mmHg at week 12 (P < 0.05) (Figure 2). Diastolic BP also significantly decreased from 78.9 ± 9.1 at baseline to 72.2 ± 9.7 mmHg at week 12 (P < 0.05) (Figure 2).

Effects of irbesartan on RAAS
As shown in Figure 3, plasma renin activity increased from 1.92 ± 2.44 ng/mL/hour at baseline to 3.19 ± 3.66 ng/mL/hour at week 12 (P < 0.05). The plasma aldosterone concentration levels were not significantly altered (388.7 ± 1045.9 pg/mL at baseline to 196.6 ± 488.51 pg/mL at week 12).

Effects of irbesartan on glucose/lipid metabolism
LDL-chol was significantly decreased (77.6 ± 19.1 mg/dL at baseline vs 72.0 ± 18.6 mg/dL at week 12) (P < 0.05) (Figure 4). HDL-chol and TG were not significantly different: the HDL-chol was 44.8 ± 17.1 mg/dL at baseline vs 45.7 ± 15.6 mg/dL at week 12, whereas the TG level was 104.3 ± 65.8 mg/dL at baseline vs 100.2 ± 59.9 mg/dL at week 12 (Figure 4). The random serum glucose and HbA1c were also not significantly different: the random serum glucose was 129.3 ± 46.9 mg/dL at baseline vs 130.6 ± 47.2 mg/dL at week 12, whereas the HbA1c was 5.8% ± 1.41% at baseline vs 5.49% ± 1.11% at week 12 (Figure 4).

Discussion
The results in the present study show that irbesartan significantly decreased systolic and diastolic BP in hypertensive HD patients. It also significantly decreased LDL-chol, whereas it did not affect HDL-chol, TG, random serum glucose, or HbA1c level. Regarding the RAAS components, plasma renin activity was significantly increased with the administration of irbesartan, suggesting negative feedback after blocking of the angiotensin II receptor.20

Table 1 Patients’ baseline characteristics

| Number | 16|
|-------|---|
| Age (years) | 62.3 ± 12.7|
| Gender | |
| Male | 15|
| Female | 1|
| Body mass index (kg/m²) | 21.1 ± 2.3|
| Duration of hemodialysis (years) | 7.6 ± 8.1|
| Initial nephropathy | |
| Chronic glomerulonephritis | 5|
| Diabetic nephropathy | 6|
| Nephrosclerosis | 1|
| Polycystic kidney disease | 1|
| Gouty kidney | 1|
| Unknown | 2|
| Systolic BP (mmHg) | 154.9 ± 12.8|
| Diastolic BP (mmHg) | 78.9 ± 9.1|
| PRA (ng/mL/h) | 1.92 ± 2.44|
| PAC (pg/mL) | 388.7 ± 1045.9|
| LDL-chol (mg/dL) | 77.6 ± 19.1|
| HDL-chol (mg/dL) | 44.8 ± 17.1|
| TG (mg/dL) | 104.3 ± 65.8|
| Random glucose (mg/dL) | 129.3 ± 46.9|
| HbA1c (%) | 5.58 ± 1.41|

Abbreviations: BP, blood pressure; HbA1c, glycosylated hemoglobin; HDL-chol, high-density lipoprotein cholesterol; LDL-chol, low-density lipoprotein cholesterol; PRA, plasma renin activity; PAC, plasma aldosterone concentration; TG, triglyceride.
Table 2 Patients’ clinical characteristics before and after irbesartan treatment

| No | Gender | Age (years) | Duration of HD (years) | Initial nephropathy | Antihypertensives (/day) | Irbesartan dose (/day) | Drugs for glucose and lipid control (/day) | BMI (kg/m²) | Baseline BP (mmHg) | Week 12 BP (mmHg) | Diastolic BP (mmHg) |
|----|--------|-------------|------------------------|---------------------|--------------------------|-----------------------|-------------------------------------------|------------|-------------------|------------------|-------------------|
| 1  | Male   | 65.1        | 1.8                    | Diabetic nephropathy| None                     | 50 mg                 | Insulin Acarbose 150 mg                  | 19.4       | 140               | 142              | 90                |
| 2  | Male   | 70.7        | 0.7                    | Polycystic kidney disease | Cilnidipine 20 mg       | 50 mg                 | None                                      | 19.7       | 150               | 145              | 80                |
| 3  | Male   | 72.0        | 1.7                    | Diabetic nephropathy | Amlodipine 10 mg        | 50 mg                 | None                                      | 23.5       | 148               | 136              | 80                |
| 4  | Male   | 79.6        | 1.2                    | Nephrosclerosis      | Nifedipine 40 mg        | 50 mg                 | None                                      | 149        | 123               | 61               | 59                |
| 5  | Male   | 66.8        | 5.8                    | Diabetic nephropathy | Nifedipine 40 mg        | 50 mg                 | Insulin Acarbose 150 mg Atorvastatin 10 mg | 25.4       | 146               | 138              | 80                |
| 6  | Male   | 54.0        | 20.3                   | Unknown              | Amlodipine 2.5 mg       | 50 mg                 | Enalapril 2.5 mg None                      | 23.7       | 152               | 140              | 76                |
| 7  | Male   | 27.4        | 1.9                    | Unknown              | Nifedipine 40 mg        | 50 mg                 | None                                      | 18.6       | 156               | 146              | 76                |
| 8  | Male   | 70.8        | 11.7                   | Chronic glomerulonephritis | Nifedipine 40 mg        | 50 mg                 | None                                      | 21.2       | 148               | 140              | 79                |
| 9  | Male   | 79.9        | 13.6                   | Chronic glomerulonephritis | None                     | 50 mg → 100 mg        | None                                      | 20.6       | 151               | 139              | 75                |
| 10 | Male   | 63.0        | 30.2                   | Chronic glomerulonephritis | None                     | 50 mg                 | None                                      | 23.6       | 161               | 125              | 82                |
| 11 | Male   | 52.7        | 14.3                   | Chronic glomerulonephritis | Amlodipine 10 mg        | 50 mg                 | None                                      | 18.0       | 150               | 136              | 92                |
| 12 | Female | 54.0        | 12.0                   | Chronic glomerulonephritis | Benidipine 1 mg         | 50 mg                 | None                                      | 19.9       | 150               | 120              | 60                |
| 13 | Male   | 48.0        | 6.0                    | Diabetic nephropathy | Benidipine 8 mg         | 50 mg                 | None                                      | 20.9       | 170               | 135              | 83                |
| 14 | Male   | 63.0        | 0.1                    | Chronic glomerulonephritis | Aliskiren 150 mg        | 50 mg                 | None                                      | 22.1       | 182               | 160              | 73                |
| 15 | Male   | 61.0        | 0.2                    | Diabetic nephropathy | Benidipine 8 mg         | 50 mg                 | None                                      | 23.7       | 183               | 173              | 91                |
| 16 | Male   | 60.1        | 4.3                    | Diabetic nephropathy | Carvediol 2.5 mg        | 50 mg                 | Pravastatin 10 mg                         | 18.3       | 143               | 134              | 85                |

Abbreviations: BMI, body mass index; BP, blood pressure; HD, hemodialysis.
Informed consent obtained  
\( n = 17 \)

Enrolled in observation period  
\( n = 17 \)

Enrolled in irbesartan treatment  
\( n = 16 \)

Symptomatic hypotension  
\( n = 1 \)

Completed study  
\( n = 16 \)

**Figure 1** Patient flow chart.

**Figure 2** Changes of systolic blood pressure (BP) and diastolic BP from baseline (week 0) to week 12.  
*Note:* \( ^* P < 0.05 \).

**Figure 3** Changes of plasma renin activity (PRA) and plasma aldosterone concentration (PAC) from baseline (week 0) to week 12.  
*Note:* \( ^* P < 0.05 \).
Cardiovascular disease is a major factor that contributes to the morbidity and mortality of HD patients. Since hypertension is a representative risk factor for the development of cardiovascular disease and has a high prevalence in HD patients, the National Kidney Foundation Kidney Disease Outcome Quality Initiative (K/DOQI) clinical practice guidelines indicate that patients’ BP before an HD session should be less than 140/90 mmHg. In the present study, irbesartan significantly decreased systolic BP and diastolic BP in hypertensive HD patients. These results suggest that irbesartan is effective in controlling BP in HD patients.

Along with hypertension, abnormalities of glucose/lipid metabolism have been reported to be risk factors for arteriosclerosis and cardiovascular diseases in HD patients. Repeated clinical studies have shown that poor glycemic control was associated with an increased risk of cardiovascular disease and mortality in HD patients. In terms of the lipid metabolism in HD patients, a clinical study reported that abnormal lipid metabolism, such as high non-HDL-chol or LDL-chol level, was associated with an increased risk of cardiovascular disease in HD patients. On the other hand, another clinical study demonstrated that cholesterol-lowering therapy provided by atorvastatin did not decrease cardiovascular events or mortality in HD patients with type 2 diabetes mellitus. As such, further studies to investigate lipid metabolism in relation to cardiovascular disease and mortality in HD patients are clearly needed. However, the very abnormal lipid metabolism was generally considered to have been corrected, the K/DOQI clinical practice guidelines recommend that non-HDL-chol should be less than 130 mg/dL in HD patients. In the present study, irbesartan significantly decreased LDL-chol in hypertensive HD patients (Figure 3). These results suggest that irbesartan would also have beneficial effects in the control of lipid metabolism in hypertensive HD patients. Random serum glucose, HbA1c, TG, and HDL-chol were not significantly decreased by irbesartan. The small number of subjects and the short study period might explain why the changes in these parameters of glucose/lipid metabolism were not significantly altered by irbesartan.

In the present study, irbesartan treatment was discontinued in one patient owing to a finding of hypotension after an HD session. This hypotension recovered to the basal level soon after the withdrawal of irbesartan. No other side effects of irbesartan, including hyperkalemia, were detected in any patients throughout the follow-up period.

There are significant limitations to the present study. First, it was a single-arm trial without a control group. However, the follow-up period was prolonged. It is considered that the results are not the influence of several variables, such as age, sex, and body weight. Therefore, future studies are needed to evaluate the long-term effects of irbesartan on cardiovascular disease and mortality in HD patients.
Second, the sample size was small, and the treatment period was short. Third, whether the improvement of lipid metabolism by irbesartan was independent of the BP lowering or not was not clear owing to the lack of control groups treated with other classes of antihypertensives. In addition, we cannot rule out the influence of cointerventions, such as the change of patients’ water and nutrition intake and lifestyle behavior, and of factors like the Hawthorne effect. Further large-scale, double-blind and long-term clinical trials are needed to confirm the efficacy of irbesartan in HD patients.

In conclusion, irbesartan significantly decreased BP and LDL-chol levels in hypertensive HD patients. These results suggest that it would be effective for BP control as well as for lipid metabolism control in hypertensive HD patients.

Disclosure

The authors report no conflicts of interest in this work.

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