Angiotensin II Subtype 1 Receptor Blockers and Renal Function

Robert Toto, MD

Blood pressure reduction is the most significant factor in delaying onset and progression of renal disease. Blockade of the renin-angiotensin system (RAS) using angiotensin-converting enzyme inhibitors (ACEIs) delays renal disease progression. More recently, agents that block the RAS by preventing angiotensin II from binding to its subtype 1 receptor (ARBs) have been developed in an effort to prevent deleterious consequences of pathologic levels of angiotensin II and to reduce the adverse effects of RAS blockade associated with ACEIs. Human studies with a variety of ARBs have clearly demonstrated the antihypertensive and antiproteinuric efficacy of these agents in patients with progressive renal diseases. Moreover, the effects of ARBs are similar or identical to those of ACEIs. Ongoing long-term clinical trials are designed to determine whether ARBs also preserve renal function similar to ACEIs. Specifically, the role of ARBs in patients with hypertension and type 2 diabetes is being evaluated in 3 large trials, including Appropriate Blood Pressure Control in Diabetes—Part 2 With Valsartan, the Losartan Renal Protection Study, and the Irbesartan Diabetic Nephropathy Trial. Definitive evidence of the long-term protective effects of ARBs in chronic progressive renal disease is expected from these important studies.

HYPERTENSION: SCOPE OF THE PROBLEM

Hypertension is a major public health problem. Serious and often fatal complications, including stroke, myocardial infarction, and renal failure, can develop if hypertension is not controlled. Hypertension is highly prevalent in diabetic and nondiabetic populations. It is estimated that from 1996 through 1998, 50 million people (or 1 in 4 adults) in the United States had hypertension defined as systolic blood pressure (BP) of at least 140 mm Hg or diastolic BP of at least 90 mm Hg.

The prevalence of hypertension varies among ethnic groups, ie, 32.4% among non-Hispanic African Americans; 23.2% among non-Hispanic whites; and 22.6% among Mexican Americans. In general, 68% of the 50 million individuals with hypertension were aware of their diagnosis, and 53% were treated with antihypertensives, but in only 27% was BP controlled with medication to less than 140/90 mm Hg. Although public awareness of hypertension, its treatment, and its control improved from 1976 to 1991, the rate of improvement in these variables has subsequently leveled off. Consequently, the US Department of Health and Human Services has set a goal to control elevated BP in at least 50% of the population by the end of 2000.

According to the United States Renal Data System, diabetes mellitus is the number one cause of end-stage renal disease (ESRD). Hypertension develops in most patients with diabetes during the course of their renal disease before starting renal replacement therapy (dialysis or transplantation). Hypertension is the second most common cause of ESRD, accounting for approximately 25% of new cases. The Sixth Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC VI) recommends that elevated BP be reduced to less than 140 mm Hg systolic and less than...
90 mm Hg diastolic, and lower if tolerated.\(^3\) Lowering BP correlates with slowing of renal disease progression, making control of hypertension in the presence of renal disease essential. Consequently, the JNC VI currently recommends that BP in the presence of renal insufficiency should be no higher than 130/85 mm Hg.\(^3\) In a recent analysis of several clinical trials on antihypertensive efficacy in hypertensive diabetic patients, Grossman et al\(^7\) demonstrated that a combination of more than 1 drug is frequently required to achieve BP control levels recommended by the JNC VI. Furthermore, in keeping with JNC VI recommendations, their analysis suggested that combination therapy may be more beneficial than monotherapy.\(^7\)

This review presents data supporting the need to control high BP to prevent progression of renal disease. In addition, it provides clinical data suggesting the additive benefit of blocking the renin-angiotensin system (RAS) while lowering BP. The discussion of blockade of the RAS will focus on the role of angiotensin II (Ang II) subtype 1 (AT\(_1\)) receptor blockers (ARBs) in the prevention of progressive renal failure.

HYPERTENSION AND RENAL FAILURE

Progressive renal insufficiency leads to ESRD. Preliminary data for 1997 show that approximately 380000 persons were treated for ESRD by means of dialysis or kidney transplantation in the United States, with the incidence of ESRD increasing annually from 1988.\(^6\) These statistics clearly indicate a substantial medical and economic burden to the individual and the country. Approximately 80% of patients in whom renal insufficiency progresses to ESRD are hypertensive during the course of the disease,\(^6\) and it is believed that uncontrolled hypertension accelerates the rate of progression in these individuals, regardless of the cause of renal failure.

Data from large clinical trials and epidemiological studies indicate that hypertension is an important risk factor for progressive renal disease. The VA Cooperative Study,\(^9\) the Hypertension Detection and Follow-up Program,\(^10\) and the Multiple Risk Factor Intervention Trial (MRFIT)\(^11\) have demonstrated that hypertension is an important risk factor for progression of renal disease. It is known that increasing age, African American race, male sex, and family history are important risk factors for development of ESRD attributed to hypertension. The severity of hypertension is directly correlated with increased risk for ESRD. The effect of elevated BP on the development of ESRD was demonstrated in men undergoing screening for entry in MRFIT (\textbf{Figure 1}).\(^11\) During a 16-year period, 847 of the 332544 men died of or were treated for ESRD. High BP was a strong and independent risk factor for the development of ESRD, with a graded relationship between risk and BP. Evolved systolic BP was especially predictive, and a relatively small increase doubled the risk for ESRD.\(^11\) Mild to moderate elevations of BP correlated with renal disease, underscoring the need for control of hypertension at all levels.\(^11\) In patients with type 2 diabetes mellitus, there is an almost linear relationship between increase in mean arterial BP and yearly decrease in glomerular filtration rate (GFR) (\textbf{Figure 2}).\(^12\)

IMPORTANCE OF LOWERING BLOOD PRESSURE IN RENAL DISEASE

Most large clinical trials of antihypertensive therapy have focused on cardiac and cerebrovascular end points. Consequently, only a few...
clinical trials have examined the effect of BP lowering on the progression of renal disease in diabetic and nondiabetic patients. Early clinical trials in hypertensive patients with renal insufficiency failed to show a significant benefit of BP lowering on decline in GFR.13 However, the target level of BP control in these studies was relatively high by present standards. For example, among the small subset of patients undergoing repeated measures of GFR during 3 to 5 years in the VA Cooperative Trial, mean treated diastolic BP was lowered to 97 mm Hg in the active treatment arm vs 117 mm Hg in the placebo arm. At 97 mm Hg, there were no differences in the rate of decline in GFR.14 In contrast, more recent clinical trials with lower target BP levels have demonstrated that lowering BP in hypertensive patients at risk for or with overt renal disease preserves renal function (Table 1).14-25 As shown in Table 1, systolic BP of about 130 mm Hg and diastolic BP of about 80 mm Hg were associated with a beneficial outcome in most studies. In the only study, to our knowledge, that focused specifically on hypertensive nephrosclerosis, our group demonstrated that lowering systolic BP to a range of 120 to 130 mm Hg and diastolic BP to a range of 70 to 80 mm Hg in patients with established renal failure and at high risk for progression to ESRD was associated with a very slow mean decline in GFR, similar to that observed with aging (approximately 0.8 mL/min per year).15

**IMPORTANCE OF REDUCING PROTEINURIA**

Proteinuria has been studied extensively as a marker for progression of renal disease.26 Individuals normally excrete protein at the rate of less than 150 mg/d. Loss of protein in the urine at a volume of greater than 200 mg/L becomes apparent by means of reagent strip findings. Under normal circumstances, urinary albumin excretion is less than 30 mg/d; microalbuminuria refers to albumin excretion of 30 to 300 mg/d.27 Microalbuminuria is a marker of risk for progression of nephropathy in patients with type 1 diabetes and of increased risk for cardiovascular death in patients with type 1 and type 2 diabetes and hypertension. Several clinical trials have shown that impaired renal function in patients with high-grade proteinuria (>1 g/d) progresses at a faster rate than for those with low-grade proteinuria (≤1 g/d).14,26 For example, in more than 400 patients with nondiabetic nephropathy, renal disease progression was slowed when protein excretion was less than 5 g/d, but progressed more rapidly when the rate of proteinuria was higher.28 The acceleration of renal disease progression in patients with types 1 and 2 diabetes correlated with the level of baseline proteinuria.29 Even in patients with controlled essential hypertension and no evidence of renal disease, the onset of proteinuria was a marker of future decline of renal function.29

The Modification of Diet in Renal Disease Study18 demonstrated that baseline proteinuria was an independent risk factor for progression of renal disease in nondiabetic patients, and the degree of proteinuria reduction might be a measure of the effectiveness of BP control. In addition, this study showed that lowering BP below the currently accepted goal to 125/75 mm Hg slows the decline in GFR, particularly in patients with proteinuria of greater than 1 g/d.14 Consequently, the investigators recommended that the BP goal for patients with proteinuria of at least 1 g/d should be 125/75 mm Hg, whereas the goal for patients with hypertension and renal insufficiency should be 130/85 mm Hg.3

**INFLUENCE OF THE RAS**

Knowledge of the basic physiological features of the RAS has greatly expanded in recent years. It is now well established that in addition to systemic Ang II production by the classic RAS,30 Ang II can be produced locally by many tissues31 and synthesized by ACE-independent pathways. Furthermore, it has been shown that the known physiologic effects of Ang II in humans are conferred by its binding to the selective AT1 receptor, which is present in various target tissues, including kidney, heart, brain, systemic vas-

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**Table 1. Clinical Trials Demonstrating That Blood Pressure Lowering Preserves Renal Function***

<table>
<thead>
<tr>
<th>Source</th>
<th>Patient Population</th>
<th>BP Control Level</th>
<th>Renal Outcome</th>
<th>ACEI Comparison</th>
<th>ACEI Superior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peterson et al14</td>
<td>Nondiabetic</td>
<td>120/80</td>
<td>Slowed decline in GFR</td>
<td>No</td>
<td>. . .</td>
</tr>
<tr>
<td>Toto et al15</td>
<td>Hypertensive, nephrosclerosis</td>
<td>130/80</td>
<td>Slowed decline in GFR</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Maschio et al16</td>
<td>Nondiabetic</td>
<td>125/75</td>
<td>Decreased risk for ESRD</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Gisen Group17</td>
<td>Glomerulonephritis</td>
<td>130/80</td>
<td>Decreased risk for ESRD</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Lewis et al18</td>
<td>Type 1 DM</td>
<td>120/80</td>
<td>Decreased risk for ESRD, doubling SCr, and death</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Kamper et al19</td>
<td>Nondiabetic</td>
<td>130/80</td>
<td>Slowed decline in GFR</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Parving et al20</td>
<td>Type 1 DM</td>
<td>140/80</td>
<td>Slowed decline in GFR</td>
<td>No</td>
<td>. . .</td>
</tr>
<tr>
<td>Zucchelli et al21</td>
<td>Nondiabetic renal disease</td>
<td>140/80</td>
<td>Slowed decline in GFR</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Hannedouche et al22</td>
<td>Nondiabetic renal disease</td>
<td>120/80</td>
<td>Slowed decline in GFR</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Ile et al23</td>
<td>Nondiabetic renal disease</td>
<td>130/80</td>
<td>Slowed decline in GFR</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Bakris et al24</td>
<td>Type 2 DM</td>
<td>130/80</td>
<td>Slowed decline in CrCr</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>UK Prospective Diabetes Study Group25</td>
<td>Type 2 DM</td>
<td>150/80</td>
<td>Decreased risk of proteinuria</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

*BP indicates blood pressure; ACEI, angiotensin-converting enzyme inhibitor; DM, diabetes mellitus; GFR, glomerular filtration rate; ESRD, end-stage renal disease; SCr, serum creatinine; Ccr, creatinine clearance; and ellipses, ACEI not used, therefore, no comment. Nondiabetic renal disease includes patients with hypertensive nephrosclerosis, glomerular disease, tubulointerstitial diseases, and autosomal dominant polycystic disease.

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Angiotensin II binds to the AT1 receptor on the cell surface of many cell types in these organs. This results in tissue-specific effects of Ang II such as sodium reabsorption in the proximal tubule and vasoconstriction of the efferent arteriole in the kidney, aldosterone release from the adrenal gland, and increased inotropy and chronotropy in the heart.30

In experimental animal models of chronic renal failure, local production of Ang II is believed to play a pivotal role in the progression of hypertensive renal diseases. Angiotensin II has multiple effects on renal function in the failing kidney that can exacerbate renal disease, including elevation of glomerular pressure, which is associated with systemic hypertension, proteinuria, and glomerulosclerosis. In addition, Ang II induces hypertrophy of glomerular and tubular cells, enhances proteinuria, and stimulates proliferation of fibroblast and mesangial cells and-secretion of collagen and extracellular matrix proteins. These effects conspire to induce chronic irreversible renal damage. Clinical and experimental data also indicate a role for renal Ang II production in the development and progression of renal disease in humans.30

Most data supporting a role for the RAS in human renal disease are derived from studies in patients with renal disorders treated with agents that inhibit Ang II formation or block Ang II receptors. These studies generally show equivalent reductions in BP and proteinuria when ACEIs and ARBs are compared.32,33 Recent evidence also indicates that intrarenal Ang II production is important in humans with renal disease.34 The relative contribution of systemic vs intrarenal Ang II production in the pathogenesis of human renal disease is unknown. In 1 study, it was estimated that ACE-independent pathways form approximately 40% of the Ang II that acts locally in the kidney.35 Regardless of the source, inhibition of Ang II production or its blockade at the receptor level has profound effects on renal function.

**EFFECTS OF ACEIS AND ARBs ON RENAL FUNCTION IN PATIENTS WITH RENAL DISEASE**

Among antihypertensive agents, ACEIs and ARBs are 2 important classes that have an impact on the RAS. In addition to their BP-lowering effects, it is well established that attenuating the effects of the RAS with ACEIs affords renoprotection independent of systemic BP control in some but not all studies (Table 1).16-19,22,24 Among other effects, interference with Ang II preferentially decreases vasoconstriction of the efferent arteriole, resulting in decreased glomerular pressure. Minimizing the effect of Ang II may also prevent its proliferative effects on the mesangium and inhibit inflammation and fibrosis.30 Both antihypertensive classes have been shown to afford renoprotection in animal models of renal failure and in humans with renal disease. Long-term studies designed to determine whether ARBs also preserve renal function are not yet completed. However, the BP-lowering and antiproteinuric effects of ARBs and ACEIs have been shown to be equivalent in patients with diabetic and nondiabetic renal diseases (Table 2).

**ACEIs in Patients With Renal Disease**

The conversion of inactive Ang I to vasoactive Ang II is inhibited by ACEIs. This decreases Ang II levels and reduces systemic BP. Because of the nonspecific substrates of ACE, the BP-lowering and renoprotective effects of ACEIs may also be related to inhibition of bradykinin degradation, resulting in increased bradykinin levels.35,36 This additional action may explain the continued antihypertensive activity of ACEIs, despite the fact that in some instances, decreases in plasma Ang II levels are not sustained with long-term administration.37 In this regard, local Ang II production via alternate enzyme pathways may contribute to the rise in Ang II levels.30

At present, the JNC VI recommends ACEIs as first-line therapy in patients with hypertension and renal dysfunction.3 Initial data sup-

**Table 2. Renal Effects of ARBs in Humans With Renal Disease**

<table>
<thead>
<tr>
<th>Source</th>
<th>Patient Population</th>
<th>ARB</th>
<th>Duration</th>
<th>Comparison or Combination</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gansevoort et al37</td>
<td>Glomerular disease</td>
<td>Losartan</td>
<td>8 wk</td>
<td>Comparison with enalapril</td>
<td>Decreased BP and proteinuria similar to enalapril maleate</td>
</tr>
<tr>
<td>Toto et al38</td>
<td>HTN, DM, ESRD</td>
<td>Losartan</td>
<td>12 wk</td>
<td>None</td>
<td>Decreased BP and proteinuria</td>
</tr>
<tr>
<td>Pitt et al39</td>
<td>CHF†</td>
<td>Losartan</td>
<td>18 mo</td>
<td>Comparison with captopril</td>
<td>Increased SCR 10.5% in both groups</td>
</tr>
<tr>
<td>Plum et al40</td>
<td>Mixed</td>
<td>Valsartan</td>
<td>6 mo</td>
<td>None</td>
<td>Decreased BP and proteinuria</td>
</tr>
<tr>
<td>Muirhead et al41</td>
<td>Type 2 DM</td>
<td>Valsartan</td>
<td>52 wk</td>
<td>None</td>
<td>Decreased BP and proteinuria, less hyperkalemia and aldosterone suppression</td>
</tr>
<tr>
<td>Bakris et al42</td>
<td>Nondiabetic</td>
<td>Valsartan</td>
<td>12 wk</td>
<td>Comparison with lisinopril</td>
<td>Synergistic effect of combination on proteinuria without additive effect on BP</td>
</tr>
<tr>
<td>Russo et al43</td>
<td>IgA nephropathy</td>
<td>Losartan</td>
<td>20 wk</td>
<td>Combination with captopril</td>
<td>Synergistic effect of combination on proteinuria and additive effect on BP</td>
</tr>
<tr>
<td>Rulöpe et al44</td>
<td>Nondiabetic renal disease</td>
<td>Valsartan</td>
<td>12 wk</td>
<td>Combination with benazepril hydrochloride</td>
<td>Decreased BP and proteinuria compared with enalapril</td>
</tr>
<tr>
<td>Andersen et al45</td>
<td>Type 1 DM</td>
<td>Losartan</td>
<td>8 wk</td>
<td>Enalapril</td>
<td></td>
</tr>
</tbody>
</table>

*Includes study by Pitt et al39 in patients with CHF without renal disease.

†Includes study by Pitt et al39 in patients with CHF without renal disease.

ARB indicates angiotensin II subtype 1 receptor blocker; HTN, hypertension; DM, diabetes mellitus; ESRD, end-stage renal disease; CHF, congestive heart failure; IgA, immunoglobulin A; BP, blood pressure; and SCR, serum creatinine.
porting the renoprotective effects of ACEIs were for patients with type 1 diabetes with nephropathy and mild renal insufficiency, with or without hypertension. Angiotensin-converting enzyme inhibitors delayed the decline in renal function, decreased proteinuria, and demonstrated a renoprotective effect independent of BP reduction or control. Reduction in the risk for overt nephropathy in patients with type 2 diabetes who are at risk was confirmed in the Microalbuminuria, Cardiovascular, and Renal Outcomes substudy of the Heart Outcomes Prevention Evaluation study. This renoprotection was also demonstrated in patients with non-diabetic nephropathy. Moreover, ACEIs provide protection from cardiac death, the most common cause of death in the population with ESRD.

ARBs in Patients With Renal Disease

As previously noted, Ang II in humans acts through receptor subtypes AT1 and AT2. The AT1 receptor is known to mediate all of the known physiologic and pathologic effects of Ang II on cardiovascular structure and function in adult humans. These effects include vasoconstriction, salt and water retention, aldosterone release and subsequent hyperkalemia, and augmentation of sympathetic activity critical to BP control. The ARBs prevent these responses to Ang II by blockade of the AT1 receptor. They also prevent the long-term effects of Ang II, including inhibition of cellular proliferation, which may affect important complications of hypertension such as vascular and left ventricular hypertrophy and the renal complication of glomerulosclerosis. By acting directly at the AT1 receptor, ARBs are purported to antagonize the actions of Ang II more completely than ACEIs. Furthermore, additional activity of ARBs may be related to stimulation of the AT2 receptor. The importance of the AT2 receptor in the remodeling process within the renal interstitium has been raised by recent observations in AT2 receptor-null mice during ureteral obstruction. The absence of the AT2 receptor in these mice results in accelerated fibrosis and collagen deposition in the interstitium. Blockade of the AT1 receptor allows Ang II to become available for AT2 receptor stimulation, potentially resulting in vasoconstriction and proliferation. The relevance of this effect has not been clearly demonstrated in humans.

EFFECTS OF ACEIs AND ARBs IN EXPERIMENTAL RENAL DISEASE

Experimental data using diabetic rat models suggested that ACEIs and ARBs have similar beneficial effects. Early studies using the ARB losartan potassium demonstrated reduced BP, proteinuria, and glomerular injury in rats with reduced renal mass. In rats with drug-induced diabetes, the ACEI ramipril and the ARB valsartan lowered BP equivalently and prevented the increase in urinary albumin excretion observed in untreated animals. Both agents attenuated glomerular structural changes similarly. In another experiment, the ACEI enalapril maleate and the ARB candesartan reduced BP comparably and inhibited proteinuria, glomerulosclerosis, interstitial fibrosis, and inflammation early in the course of treatment in partially nephrectomized rats. However, only candesartan prevented the late progression of glomerulosclerosis and interstitial fibrosis.

Additional studies in a rat model of hypertensive nephrosclerosis have shown that 22 weeks of treatment with the ACEI delapril hydrochloride or the ARB candesartan produced equivalent renoprotection (reduction in proteinuria and glomerulosclerosis) compared with untreated control rats. Similarly, in a study of uninephrectomized hypertensive rats, the ACEI enalapril and the ARB irbesartan decreased BP to within the reference range, lowered proteinuria, markedly reduced glomerulosclerosis, and decreased glomerular capillary pressure while maintaining GFR. Conversely, hypertension, proteinuria, and elevated glomerular capillary pressure developed in untreated rats. A study in spontaneously hypertensive rats showed that the ACEI captopril and the ARBs telmisartan and losartan reduced BP similarly and attenuated renal damage by significantly decreasing urinary albumin level and glomerulosclerosis. In another study, treatment of male diabetic Munich-Wistar Froemter rats with the ARB valsartan or the ACEI benazepril hydrochloride resulted in normalized systemic and glomerular capillary BP, prevention of proteinuria, and minimized glomerulosclerosis. Eprosartan mesylate, a newer ARB, has also been shown to be renoprotective in 5 of 6 nephrectomy models of progressive renal disease in rats. Taken together, these studies provide strong evidence that the BP-lowering and renoprotective effects of ARBs are comparable to those of ACEIs in a variety of animal models of chronic, progressive renal disease.

RENAL EFFECTS OF ACEIs AND ARBs IN HUMANS WITH CHRONIC RENAL DISEASE

Short-term Studies

Recent clinical studies involving small numbers of patients with follow-up ranging from 1 to 18 months demonstrated the effectiveness of ARBs in lowering blood pressure and proteinuria in patients with chronic renal disease (Table 2). In one study, losartan produced a fall in BP, a dose-related decline in proteinuria, and improved renal hemodynamics with stable GFR in 13 hypertensive patients with renal disease. In another study, losartan alone or in combination with other antihypertensive agents decreased BP and stabilized creatinine clearance and renal hemodynamics in 112 hypertensive patients with renal disease. In a study comparing losartan with amlodipine, losartan alone or in combination with amlodipine produced equivalent BP reduction and renoprotection.

Table 2. Effect of ARBs and ACEIs on Proteinuria in Human Renal Disease

<table>
<thead>
<tr>
<th>Study Type</th>
<th>Number of Patients</th>
<th>Duration</th>
<th>BP Reduction</th>
<th>Proteinuria Reduction</th>
<th>Renoprotection</th>
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</thead>
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<tr>
<td>Short-term</td>
<td>112</td>
<td>6 months</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Short-term</td>
<td>13</td>
<td>6 months</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>


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in renal hemodynamics, and a 20% to 40% reduction in total urinary protein and albumin excretion. In a larger study, valsartan and captopril lowered BP and decreased microalbumin excretion significantly better than placebo in 122 normotensive and treated hypertensive patients with type 2 diabetes and nephropathy.8,41,71 Combinations of ACEIs and ARBs in patients with hypertension and impaired renal function have shown that combination therapy results in synergistic effects to reduce proteinuria with or without concomitant synergistic reduction in systemic BP.42,43 As can be seen, most renal studies to date have been performed with losartan. Whether newer agents will have a more powerful effect on renal function in patients with hypertensive renal disease remains to be determined. At this time, there are no studies comparing losartan directly with other ARBs on renal function.

Long-term Studies

Taken together, these studies in patients with chronic renal disease show that ARBs effectively lower BP and reduce proteinuria similar to ACEIs. However, the question remains as to whether the ARBs offer long-term renal protection similar to the ACEIs in similar diseased populations. Several trials are under way to answer this question. These trials include the Appropriate Blood Pressure Control in Diabetes—Part 2 With Valsartan trial, which is assessing the effects of intensive vs moderate BP control on nephropathy in normotensive and hypertensive patients with type 2 diabetes72; the Losartan Renal Protection Study, which is evaluating the renoprotective effects of losartan in patients with type 2 diabetes and nephropathy73; and the Irbesartan Diabetic Nephropathy Trial, which is comparing the effectiveness of irbesartan vs amlodipine vs placebo in preservation of renal function and overall mortality in patients with type 2 diabetic nephropathy.74,75

SAFETY AND EFFICACY OF ARBs

The efficacy, tolerability, and safety of ARBs have been established in clinical trials with other antihypertensive agents.71,76 The ARBs provide once-a-day dosing with a profile of adverse effects comparable to that of placebo,79 whereas the ACEIs have been limited by the development of a dry cough, which is seen in 5% to 20% of patients.77 Results of recently completed clinical trials showed that ARBs are better tolerated than ACEIs, with fewer patients terminating treatment prematurely.39,78 The Evaluation of Losartan in the Elderly (ELITE) I Study was a randomized, double-blind study designed to evaluate the safety and tolerability of the oral ACEI captopril (50 mg 3 times daily) and the oral ARB losartan potassium (50 mg/d). The primary end point of the trial was a persistent increase in serum creatinine level of greater than 25% above baseline. After 18 months of follow-up, the incidence of hypercreatininemia was 10.5% in both groups. Thus, there was no difference in the incidence of persistent renal dysfunction in elderly patients with symptomatic heart failure treated with captopril compared with losartan.79 In ELITE II, survival during 8 months of treatment with losartan was shown to be equivalent to captopril in elderly patients with congestive heart failure. Losartan was better tolerated than captopril.78

All agents that block the RAS, including ACEIs, ARBs, and aldosterone receptor antagonists, may cause hyperkalemia, particularly in patients with renal impairment. However, the incidence of hyperkalemia in several studies using ARBs, including losartan and valsartan, indicate that the likelihood of hyperkalemia is relatively low.51,38,42,43 In a crossover study involving patients with chronic renal disease, valsartan compared with lisinopril did not significantly increase serum potassium levels.52 However, in a short-term study of patients with advanced renal failure with or without hypertension, valsartan, 160 mg/d, as monotherapy or in combination with benazepril (valsartan, 80 or 160 mg/d, and benazepril hydrochloride, 5 or 10 mg/d) increased serum potassium levels.44 In general, the incidence and severity of hyperkalemia is lower in ARB-compared with ACEI-treated patients with chronic renal disease.53,38,42,44

CONCLUSIONS

This review stresses the significance of hypertension as an etiologic component in the development of renal failure. The evidence presented demonstrates that control of hypertension slows the inevitable decline of renal function after renal abnormalities are identified. The ARBs are effective and safe antihypertensives. They selectively block AT1 receptors and have potential advantages compared with ACEIs because of their safety and tolerability profile. Data from short-term studies suggest that ARBs are equivalent to ACEIs in prevention of progressive renal disease. However, this needs to be confirmed in long-term clinical trials. Current ongoing studies have been designed to establish the long-term impact of ARBs on renal function.

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Corresponding author and reprints: Robert Toto, MD, Patient-Oriented Research in Nephrology, University of Texas Southwestern Medical Center, 5323 Harry Hines Blvd, Dallas, TX 75390-8856 (e-mail: robert.toto@utsouthwestern.edu).

REFERENCES


