Blood Pressure Evaluation among Older Living Kidney Donors

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Abstract. With more patients reaching end-stage renal disease, the demand for living kidney donation is increasing rapidly. Many potential donors are now in older age groups. The effects of increasing BP with age and the measurement criteria for hypertension in this group are not well defined. A total of 238 potential donors between 18 and 72 yr of age were prospectively studied, with a comparison of “clinic” BP values measured in the outpatient clinic with an oscillometric recorder (Dinamap; Critikon), ambulatory BP monitoring (ABPM) findings, and standardized BP values determined by nurses using American Heart Association criteria. Renal function was evaluated on the basis of iothalamate clearance (GFR) and urinary protein and microalbumin excretion. Ninety-six percent of subjects were Caucasian. All subjects exhibited normal GFR and urinary protein excretion. Three age groups were defined (group I, ≤35 yr, n = 64; group II, 36 to 49 yr, n = 109; group III, ≥50 yr, n = 65). BP increased with age, as determined with all methods. Subjects ≥50 yr of age exhibited the highest clinic readings (145 ± 2/83 ± 1 mmHg, compared with 129 ± 2/76 ± 1 mmHg for group I, P < 0.01). Awake ABPM and nurse-determined BP measurements were lower than clinic readings, including those for group III (131 ± 2/80 ± 1 mmHg, compared with 145 ± 2/83 ± 1 mmHg in the clinic, P < 0.001). With the use of systolic BP values of >140 mmHg and/or diastolic BP values of >90 mmHg, 36.7% of subjects were initially considered hypertensive; this proportion decreased to 11% overall with awake ABPM findings (>135/85 mmHg). Measurement variability (SD in ABPM) and the effects of misclassification were greatest for donors ≥50 yr of age. Multivariate regression indicated that GFR of both donors and recipients decreased with age, but regression identified no independent effect of BP. Recipient outcomes for up to 2 yr were equally good for donor kidneys considered normotensive or hypertensive on the basis of clinic BP measurements. These data indicate that higher arterial BP with age can lead to misclassification of many older living kidney donors. Sixty-two subjects with excellent kidney function were misclassified as hypertensive with clinic oscillometric measurements alone. Detailed evaluations of ABPM findings, GFR, and urinary protein levels are warranted for Caucasian subjects with high clinic BP readings who are otherwise suitable potential donors.

Demand for renal transplants continues to increase, in part because of increasing numbers of patients reaching end-stage renal disease. Improved clinical results with renal allografts reflect advances in immunosuppressive therapy and medical management. For many patients who reach end-stage renal disease, transplantation offers advantages with respect to both quality of life and survival time, compared with hemodialysis (1). One result of these trends is an ever-expanding waiting list for cadaveric kidneys. Waiting times now reach several years for many blood types (2).

These developments favor expansion of living donor kidney transplant programs. Outcomes achieved with living donors, whether genetically related to the recipient or not, seem to be as good as or better than those achieved with cadaveric donors (3). Many transplant programs, including our own, now evaluate a wider range of potential living donors than ever before. More of these individuals are in older age groups, which predisposes them to more comorbid medical conditions (including higher arterial BP), compared with younger donors. As a result, careful assessment of factors important for donor selection, such as BP, is essential.

Reasons for exclusion of potential donors vary widely among transplant centers (4). Criteria commonly include hypertension, older age, and obesity, in addition to obvious systemic illnesses and kidney disease (5,6). Hypertension, which is usually defined as clinically measured BP values above 140/90 mmHg or the need for antihypertensive medication, is one of the most common reasons for exclusion of donors who might otherwise be suitable (7).

Reliable assessment of hypertension during office evaluations is difficult. BP measurements are recognized as being prone to many inaccuracies (8,9). Common errors include improper technique, inattention to patient preparation, seating, leg and foot support, and arm support, and exclusion of tobacco.
and caffeine ingestion within specified times (8,10). More difficult to address are the effects of "office" or "white coat" hypertension, which tends to elevate BP during office visits beyond values evident at any other time (11). To what degree variations in BP measurements affect the evaluation and selection of renal donors is not precisely known.

We sought to examine the effects of BP measurement techniques on the classification of potential donor candidates. We compared standard office BP measurements with an automated oscillometric device with values obtained by specialized hypertension nurses trained to follow American Heart Association guidelines for multiple office readings and with values obtained in overnight ambulatory BP monitoring (ABPM) conducted completely outside the office environment. Our results indicate that older donor candidates exhibit higher arterial BP values and greater BP variability, compared with younger donors. Reliance on automated clinic measurements of BP commonly leads to misclassification of BP, which unnecessarily excludes excellent donor candidates.

Materials and Methods

Consecutive living kidney donor candidates (n = 238) who underwent evaluation in 2000 or 2001 were included in this study. The subjects were evaluated according to accepted donor guidelines (5) as part of the Mayo Kidney-Pancreas Transplant Program, with a complete history, physical examination, and laboratory evaluation. No patient was previously identified as hypertensive or was taking antihypertensive medication at the time of the evaluation. GFR was measured as the clearance of subcutaneously administered iothalamate during water diuresis (12). Results were expressed as milliliters per minute per 1.73 m². Imaging of the kidneys and renal arteries was performed with computed tomographic angiography. Urinary protein, sodium, and microalbumin levels were measured in 24-h samples. Body surface area was determined from height and weight measurements, during the initial visit. Family histories of hypertension were recorded during interviews with the hypertension nurses; individuals were asked to report known or treated hypertension among first-degree relatives. Smoking status was defined as current or recent (within 6 mo) cigarette smoking. Race and/or ethnic origins were self-reported.

BP measurements were obtained under several different conditions. Clinic BP measurements were defined as those obtained by clinic staff using an automated oscillometric device (Dinamap; Critikon, Tampa, FL), in sitting and standing positions. These measurements were obtained during quiet sitting at a recording station. An overnight automated ABPM monitor (Spacelabs, Issaquah, WA) was then placed for 24 h for analysis of 5-h blocks of "awake" and "inactive" BP values, as described previously (13). Circadian rhythm (day/night difference) was determined as the average awake readings minus the average inactive readings recorded during continuous 5-h periods. A 2-h transition period between the awake and inactive periods was omitted, to eliminate the variable effects of sleep initiation (14,15). On a separate occasion, a trained hypertension therapy nurse obtained three seated measurements. Care was taken to ensure at least 5 min of quiet rest, using American Heart Association standards for arm support, cuff size, and body positioning (8,16). The mean of these values was taken as the nurse-determined measurement. For clinic or nurse-determined BP readings, repeated measurements of systolic BP of >140 mmHg or diastolic BP of >90 mmHg were defined as hypertension. For ABPM determinations, mean awake systolic BP values of >135 mmHg or diastolic BP values of >85 mmHg were considered elevated (17).

For individuals who completed pretransplant evaluations and organ donation, posttransplant measurements of GFR in the recipient were obtained before dismissal from clinic follow-up monitoring (usually 3 to 4 wk after transplantation). Follow-up values for serum creatinine levels were obtained for the 1-yr and last follow-up time points (mean, 581 d).

Demographic and BP data were recorded in an Excel worksheet (Microsoft, Seattle, WA). Statistical analyses were performed by using Systat software (Evanston, IL) (18). Comparisons among age groups for normally distributed data were performed by using ANOVA, with groupwise comparisons for significant results. Comparisons of dichotomous variables were performed with chi-squared analyses. Data are presented as mean ± SEM unless otherwise indicated. Multivariate regression analyses were performed with forward stepwise modeling procedures.

Results

Demographic characteristics of the donors undergoing evaluation are summarized in Table 1. The subjects were divided into three age groups (group I, ≤35 yr, n = 64; group II, 36 to 49 yr, n = 109; group III, “older donors,” ≥50 yr, n = 65). Overall, 59.2% of living donors were female. Body surface areas did not differ among the age groups. Urinary sodium excretion values were typical of those for the United States population. Urinary protein excretion and microalbumin excretion were normal. GFR, as reflected by iothalamate clearance, was lower for the older donors (84 ± 2 ml/min per 1.73 m² versus 104 ± 2 and 99 ± 1 ml/min per 1.73 m², group III versus groups I and II, respectively, P < 0.01) but remained within the age-adjusted normal range, as defined in our laboratory (19). The proportion of current or recent smokers in the oldest group was lower than that observed for the younger donors (20.0% versus 37.5%, P = 0.02). Rates of self-reported family histories of hypertension were 58 to 67% for all groups. Ninety-six percent of donors evaluated were Caucasian.

BP values, as determined with clinic oscillometric assessments, 18-h ABPM, and transplant nurse visits, are summarized in Tables 2 and 3. Mean systolic and diastolic BP values increased with increasing age, as determined with all measurement methods. The mean clinic BP readings obtained with an automated oscillometric unit (Dinamap) increased from 129 ± 2/76 ± 1 mmHg in group I to 145 ± 2/83 ± 1 mmHg in group III (P < 0.001). Awake BP values measured with an ABPM unit (average of 30 readings during a 5-h period) increased from 122 ± 1/75 ± 1 mmHg in group I to 131 ± 2/80 ± 1 mmHg in group III (P < 0.001). A similar change in BP readings with age was apparent for values obtained by trained hypertension nurses, according to American Heart Association standards (Table 2).

Clinic BP values were higher than both ABPM values and nurse-determined values for each age group. The magnitude of this difference varied for individual subjects, but group average values were 10 to 14 mmHg higher, compared with ABPM awake time blocks (Table 2). For group III subjects, clinic BP values were 145 ± 2/83 ± 1 mmHg, compared with ABPM values of 131 ± 2/80 ± 1 mmHg (P < 0.001). Nurse-deter-
mined BP values were similar to those obtained by ABPM during awake periods and were lower than those obtained with the clinic device (nurse-determined BP, 130/110 mmHg, P < 0.001 versus clinic values). A comparison of nocturnal and awake ABPM readings indicated a normal diurnal pattern of BP decreases for all age groups. The day/night differences were 14 to 15/12 to 15 mmHg. As a result, combined day/night BP values obtained with ABPM were lower for each age group. Heart rate decreased 13 to 15 beats/min during the overnight period. The variability of systolic BP, defined as the SD of all BP values during the interval, increased with age (from 9.9 ± 0.6 mmHg to 12.6 ± 1 mmHg, P < 0.01). Therefore, the likelihood of widely varying readings in repeated measurements was highest for older donors. This variability compounded the effect of higher BP in this group, with respect to the diagnosis of hypertension. Generally, although not universally, awake ABPM and nurse-determined BP classifications were in agreement. Fourteen of 40 patients (35%) with ABPM-indicated hypertension were ultimately considered to have normal or high-normal BP. Rarely, individuals with normal office BP values demonstrated elevated ABPM readings (five of 144 patients, 3.5%).

The proportion of subjects classified as hypertensive on the basis of clinic oscillometric readings increased with increasing age (Table 2), from 21% in the youngest cohort to 62% in group III. The numbers of such subjects decreased in all groups if either ABPM or nurse-determined BP readings were considered diagnostic of clinically relevant hypertension (Figure 1). The proportions decreased to 4% in groups I and II and the proportion decreased from 62% to 31.6% in group III with standardized nurse-determined BP readings, compared with clinic values (P < 0.001). Reclassification of BP status resulted in the number of identified hypertensive subjects decreasing from 88 to 26 of the 238 candidates.

Multivariate analysis was performed, with stepwise model construction, to examine whether arterial BP predicted GFR for this set of kidney donors. The strongest predictor of iothalamate clearance was age (Figure 2). Urinary protein and microalbumin levels were positively correlated with GFR. Clinic systolic BP values and nurse-determined systolic and

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Table 1. Demographic characteristics of 238 living donors

<table>
<thead>
<tr>
<th>Group</th>
<th>Group I (≤35 yr)</th>
<th>Group II (36 to 49 yr)</th>
<th>Group III (≥50 yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>29 (18 to 35)</td>
<td>41.6 (36 to 49)</td>
<td>58.4 (50 to 72)</td>
</tr>
<tr>
<td>Gender (F/M)</td>
<td>34/30</td>
<td>64/45</td>
<td>43/22</td>
</tr>
<tr>
<td>Creatinine level (mg/dl)</td>
<td>1.09 ± 0.02</td>
<td>1.06 ± 0.01</td>
<td>1.06 ± 0.02</td>
</tr>
<tr>
<td>Smokers (%)</td>
<td>37.5 (24/64)</td>
<td>24.7 (27/109)</td>
<td>20 (13/65)</td>
</tr>
<tr>
<td>Family history (%)</td>
<td>67.2 (41/61)</td>
<td>67.3 (72/107)</td>
<td>58.1 (36/62)</td>
</tr>
<tr>
<td>Body surface area (m²)</td>
<td>1.99 ± 22</td>
<td>1.95 ± 20</td>
<td>1.95 ± 19</td>
</tr>
<tr>
<td>GFR (ml/min per 1.73 m²)</td>
<td>104 ± 2</td>
<td>99 ± 1</td>
<td>84 ± 2</td>
</tr>
</tbody>
</table>

Urine levels

- sodium (mEq/d) | 160 ± 9 | 169 ± 7 | 159 ± 11 |
- protein (mg/d) | 44 ± 7  | 42 ± 2  | 43 ± 3  |
- microalbumin (mg/d) | 12.8 ± 2.7 | 12.2 ± 3 | 8.8 ± 1.0 |

*P < 0.05, compared with groups I and II.

Table 2. Clinic and transplant nurse-recorded BP for 238 living donors

<table>
<thead>
<tr>
<th>Transplant nurse</th>
<th>Group I (n = 64)</th>
<th>Group II (n = 109)</th>
<th>Group III (n = 65)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBP (mmHg)</td>
<td>118 ± 1b</td>
<td>119 ± 1b</td>
<td>130 ± 2b,c</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>70 ± 1b</td>
<td>73 ± 1b</td>
<td>76 ± 1b,c</td>
</tr>
<tr>
<td>SBP &gt; 140 mmHg (%)</td>
<td>3.6</td>
<td>3.8</td>
<td>31.6</td>
</tr>
<tr>
<td>Clinic (Dinamap)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>129 ± 2</td>
<td>133 ± 2</td>
<td>145 ± 2c</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>76 ± 1</td>
<td>78 ± 1</td>
<td>83 ± 1c</td>
</tr>
<tr>
<td>SBP &gt; 140 mmHg (%)</td>
<td>21</td>
<td>32.4</td>
<td>62c</td>
</tr>
</tbody>
</table>

*SBP, systolic BP; DBP, diastolic BP.

b P < 0.01 compared with clinic oscillometric readings.

c P < 0.05, compared with groups I and II.
BP values were weakly related in univariate regressions, but those effects disappeared when age was included. After inclusion of age and body surface area, no independent effect of BP on GFR could be detected (Table 4). Recipient measures of GFR early after transplantation are presented in Figure 3. The iothalamate clearance of recipients of transplants from older donors was lower than that of recipients of transplants from younger donors within the first 1 mo after transplantation (51 ± 3 ml/min per 1.73 m² for group III versus 62 ± 4 ml/min per 1.73 m² for group I, P < 0.01). After correction for donor age, no independent role for donor BP in predicting early renal function among the recipients of these kidneys could be detected. Serum creatinine levels for recipients at the last follow-up visit (mean, 581 d) are summarized in Table 5. The results were divided into normal and elevated BP groups, as defined for each BP measurement method. They were further divided into groups with and without individuals with identified hypertension who were later treated with antihypertensive medications. No differences were evident with respect to early graft loss or rejection episodes. Among 36 recipients of transplants from donors who demonstrated elevated BP values in office measurements, the mean follow-up creatinine level was 1.58 ± 0.5 mg/dl. This value was indistinguishable from values for recipients with normal donor BP, as determined with office readings (1.56 ± 0.6 mg/dl), awake ABPM measurements (1.58 ± 0.6 mg/dl), or hypertension nurse-determined readings (1.57 ± 0.7 mg/dl). For this set of subjects, donor BP did not predict recipient renal functional outcomes for up to 2 yr after transplantation.

**Discussion**

The results of this study demonstrate major differences in the classification of arterial BP among potential living kidney donors with different methods of BP evaluation. Our findings indicated that BP values assessed with all methods were higher among older donors (>50 yr) and were more variable in that group. As a result, classification as hypertensive was far more likely for older donors than for younger donors, particularly if...
casual BP values obtained with automated clinic devices were primarily used. Reclassification of BP status on the basis of nurse-determined BP values and ABPM findings reduced the number of candidates identified as hypertensive and allowed 62 donor candidates to be considered further than they might otherwise have been. These findings suggest that donors with no evidence of renal dysfunction (as indicated by measured GFR and urinary microalbumin levels) frequently are misclassified as hypertensive and are likely excluded from organ donation. Although advanced donor age was associated with slightly reduced renal function among recipients, no additional adverse effects of donor BP were detected, in the BP ranges studied here.

Until recently, living donors represented the source of a minority of transplanted kidneys. Several forces have changed the situation, including the increasing number of individuals reaching end-stage renal disease who are considered transplant candidates (2). With growing waiting times for cadaveric kidneys in the United States and convincing data that outcomes and quality of life with a functioning allograft are better than

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**Fig. 2.** Examples of scatterplots and univariate regressions of data for living kidney donor candidates, examining GFR (iothalamate clearance) as a function of age (A) and average awake systolic BP (wake ave SBP) (B). GFR decreased with age ($r = -0.58, P < 0.001$), but no relationship was evident with any BP measurements in this cohort (awake systolic or diastolic BP, clinic systolic or diastolic BP, or nurse-determined systolic or diastolic BP).
widespread application of laparoscopic nephrectomy results in lower morbidity for donors, even those at older ages. With improvements in immunosuppressive therapy, even unrelated donors can provide excellent allograft function (20,21). Many unrelated donors and recipients are spouse pairs; the chance to donate a kidney presents an opportunity for the donor to assist the marriage partner and directly determine the pattern of their life together. Evaluation of such donor candidates must be particularly complete and careful, because the consequences of disallowing a transplant might be catastrophic.

Hypertension of potential donors is commonly listed as an exclusion criterion (7). The reasons for this exclusion seem to be based primarily on the concern that individuals with hypertension face increased future risks of developing kidney failure (e.g., nephrosclerosis) (22–24). On the basis of epidemiologic data, high BP does predict the risk of renal failure for specific population groups (e.g., African Americans) (25). An additional concern is the potential for hypertensive donors to yield worse allograft outcomes, as suggested by results with cadaveric donors (26,27). The BP level that indicates a renal injury risk is not well defined. The data presented here underscore the ambiguity of arbitrary definitions of hypertension, particularly when a single threshold is used. It must be emphasized that criteria defining high BP have been lowered in the past 20 yr. The results of long-term follow-up monitoring in hypertension treatment trials, however, led some to question whether Caucasian subjects with normal urinalysis findings and GFR face any meaningful excess risk of renal failure (22). Many more subjects are now being considered for living kidney donation at older ages than before. Many of the individuals evaluated at 50 to 60 yr of age who are identified as having elevated BP, according to current standards, would almost certainly have demonstrated normal BP if they had been evaluated at 25 to 35 yr of age. Therefore, they represent members of the same population group, simply appearing at different ages. Our concern that older Caucasian donors frequently may be unnecessarily excluded from living kidney donation prompted this study.

Population-based surveys in western countries have long established that arterial BP increases with age (29). With such increases and increased BP variability, as demonstrated by our data, accurate classification of BP becomes more difficult among older age groups, particularly when a single cutoff point for defining hypertension is applied. ABPM allows the collection of multiple readings outside the office setting. It is recognized to provide a measure of the average BP “load,” which is more precisely correlated with hypertensive target injury than are office BP measurements alone (17,30). Previous studies of potential transplant donors are limited but confirm our observation that ABPM findings often differ from office readings. Ozdemir et al. (31) compared ABPM findings and office readings for 86 donors, in relation to electrocardiographic and ophthalmologic evidence of hypertensive injury. They observed that 13 of 37 donors with office-determined hypertension were entirely normotensive with ABPM, without evidence of target injury.

Practices regarding BP evaluation of potential donors seemed to vary widely among centers, when inquiries were made on behalf of the American Society of Transplant Physicians (now the American Society of Transplantation) (4). Up to one-third of transplant centers allowed minor elevations in BP, including treated hypertension if it was controlled (4). Few published data on the evaluation of transplant donors systematically addressed methods of determining BP status or classifying individuals as hypertensive.

The pitfalls of BP measurement and misclassification are widely recognized in the hypertension and preventive cardiology literature. Most risk data are derived from BP measurements obtained during office visits, as opposed to home BP readings or ABPM readings (32). Recent studies indicated that office or white coat hypertension is common and may lead to

Table 4. Results of univariate and multivariate regression models predicting GFR among 238 living renal donor candidates between 18 and 72 yr of agea

<table>
<thead>
<tr>
<th>Factor</th>
<th>r</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>−0.58</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Microalbumin</td>
<td>0.074</td>
<td>0.02 (0.035 after including age)</td>
</tr>
<tr>
<td>Total protein</td>
<td>0.088</td>
<td>0.02 (0.06 after including age)</td>
</tr>
<tr>
<td>Gender</td>
<td>N/A</td>
<td>0.860</td>
</tr>
<tr>
<td>Clinic SBP</td>
<td>N/A</td>
<td>0.07 (0.877 after including age)</td>
</tr>
<tr>
<td>Clinic DBP</td>
<td>N/A</td>
<td>0.266</td>
</tr>
<tr>
<td>Awake SBP</td>
<td>N/A</td>
<td>0.268</td>
</tr>
<tr>
<td>Awake DBP</td>
<td>N/A</td>
<td>0.429</td>
</tr>
<tr>
<td>Nurse-recorded SBP</td>
<td>N/A</td>
<td>0.191</td>
</tr>
<tr>
<td>Nurse-recorded DBP</td>
<td>N/A</td>
<td>0.139 (0.989 after including age)</td>
</tr>
</tbody>
</table>

N/A, not applicable; SBP, systolic BP; DBP, diastolic BP. No individual had been previously identified as hypertensive and all were considered to have normal GFR, urinary protein levels, and microalbumin excretion.
overestimation of arterial BP (and, by extension, unnecessary treatment for hypertension) for 18 to 25% of subjects (33–35). The office effect seems to be attributable to many factors, including a stress reaction among susceptible individuals, anxiety related to seeing a physician (36), failure to exclude smoking or caffeine exposure before measurement, and improper cuff size, positioning, or technique, among others. Other studies indicated that some oscillometric devices, including those commonly used in clinic settings, are susceptible to systematic errors (9). International evaluating organizations have recognized the limited accuracy and precision of automated oscillometric units (37). The magnitude of these effects and their clinical impact depend on the interpretation of the measurements. Our results indicate that, for kidney donor candidates in older age groups and/or with high office BP readings, further evaluation is warranted before the diagnosis of hypertension is established.

ABPM has been proposed as a means of minimizing errors in BP evaluation. It is time-consuming and expensive but provides multiple measurements that can be obtained during a variety of activities, in different locations. Recent studies indicated that ABPM findings estimated more accurately than did office readings the risks of BP-related vascular injury, including small-vessel cerebrovascular disease (30,38), microalbuminuria (39), and left ventricular hypertrophy (40). Occasionally, ABPM readings indicate more elevated BP outside the clinic (“isolated ambulatory hypertension”) (41). This is observed primarily among subjects >70 yr of age. Our results confirm previous observations indicating lower ABPM values, compared with routine clinic measurements. Most importantly, the results identified individuals with normal arterial BP despite office hypertension (36). Prospective ABPM measurements in treatment trials involving elderly hypertensive individuals indicated that the cardiovascular risks of white coat hypertension are extremely low (30). Recent Medicare regulations acknowledge this benefit and authorize reimbursement, under specified conditions, for ABPM. Our results indicate that ABPM measurements can allow more appropriate kidney donor selection than do office-based readings, which might considerably expand the eligible donor pool, particularly among older subjects. Alternatively, multiple measurements by a trained nurse, following American Heart Association recommendations regarding rest, positioning, and temperature control, can provide similar values.

Are potential kidney donors with high office BP readings but normal ABPM or nurse-determined BP values at higher risk for future renal disease? Our data do not directly address this question. It should be emphasized that this group of potential donors did not have previously identified hypertension and the results of all other tests of kidney function and protein excretion were considered normal. Within these constraints, our multivariate analysis did not identify an independent role for BP in predicting kidney function, beyond that attributable to age (19). This observation applied to predictions of both donor GFR before donor nephrectomy and recipient GFR after transplantation. In contrast to reported results with deceased donors, recipient graft function with living donors did not depend on donor BP classification in any respect (Table 5). We interpret our results as indicating that many potential living donors with high-normal arterial BP values, who might otherwise be excluded, can be offered the opportunity to donate a kidney. It should be emphasized that our donor population represented almost exclusively Caucasian subjects. Our results should not be assumed to extend to other population groups, particularly African Americans. Follow-up studies of living kidney donors, including recent surveys of donors monitored for 20 to 30 yr, did not identify higher than expected risks of either kidney disease or other types of morbidity (4,42,43). Remarkably, older donors demonstrated the ability to develop compensatory hypertrophy to a similar degree, compared with younger donors (19). Some authors suggested higher than expected incidences of hypertension and/or microalbuminuria among older donors (44). Recent studies included many early donors who
later developed glucose intolerance and hypertension, as expected for the aging general population (43). Despite the reassuring experience with previous outcomes, it must be recognized that recent donor practices represent a loosening of the exclusion criteria. Current donor groups include more older subjects, with greater comorbid cardiovascular disease risks and higher arterial BP. These practices necessitate close attention to the outcomes and consequences of kidney donation. It cannot be assumed that the benign long-term results associated with the stricter criteria of 20 yr ago extend to these donors. Our results demonstrate that careful assessment of BP can expand the pool of living kidney donors, particularly in older age groups, with excellent allograft outcomes. These results indicate that further assessment of multiple BP readings by trained nurses or ABPM should be considered for individuals in older age groups or with higher BP in initial clinic examinations. Meticulous follow-up monitoring of these living kidney donors will require equally close attention to BP and target organ injury in the years after organ donation.

References

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**Table 5. Serum creatinine levels for 124 living renal donor allograft recipients, divided by donor BP classification**

<table>
<thead>
<tr>
<th>Clinic (Dinamap, Oscillometric)</th>
<th>ABPM (Wake) (Spacelabs)</th>
<th>Hypertension Nurse</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Threshold BP</strong></td>
<td><strong>Creatinine (mg/dl)</strong></td>
<td><strong>n</strong></td>
</tr>
<tr>
<td>Excluding treated hypertension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>normal</td>
<td>≤140/90</td>
<td>1.56 ± 0.6</td>
</tr>
<tr>
<td>high</td>
<td>&gt;140/90</td>
<td>1.58 ± 0.5</td>
</tr>
<tr>
<td>Including treated hypertension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>normal</td>
<td>≤140/90</td>
<td>1.55 ± 0.6</td>
</tr>
<tr>
<td>high</td>
<td>&gt;140/90</td>
<td>1.57 ± 0.7</td>
</tr>
</tbody>
</table>

*Mean time to last follow-up visit, 581 days; ABPM, ambulatory BP monitoring.*

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