Cost-Effectiveness of Ambulatory Blood Pressure

A Reanalysis

Lawrence R. Krakoff

Abstract*—**Accurate diagnosis of hypertension and prognosis for future cardiovascular events can be enhanced through the use of 24-hour ambulatory blood pressure monitoring. It has been suggested that the use of ambulatory monitoring as a secondary screening for hypertension might be cost-effective. Many needed studies that are related to the calculation of cost-effectiveness for ambulatory monitoring have become available in recent years. More accurate estimates for cost of care, costs for testing, prevalence of white-coat hypertension, and incidence of the transition from normal pressures to hypertension have been reported. This study presents calculations of the cost savings likely to take place when ambulatory blood pressure monitoring is implemented for newly detected hypertensive subjects. These calculations are based on current estimates for cost of testing, cost of treatment, prevalence of white-coat hypertension at baseline, and varying the incidence of new hypertension after the initial screening. The results indicate a potential savings of 3% to 14% for cost of care for hypertension and 10% to 23% reduction in treatment days when ambulatory blood pressure monitoring is incorporated into the diagnostic process. At current reimbursement rates, the cost of ambulatory blood pressure monitoring for secondary screening on an annual basis would be <10% of treatment costs. Calculated savings for use of ambulatory blood pressure monitoring can take place when annual treatment costs are as little as $300. These estimates should be considered for the management of recently detected hypertension, especially when the risk of future cardiovascular is disease is low. (Hypertension*. 2006;47:29-34.)**

Key Words: ambulatory blood pressure monitoring, ambulatory ■ hypertension, white-coat ■ cost benefit analysis

Prospective surveys have established the value of ambulatory blood pressure monitoring (ABPM), compared with, or additive to, clinic pressures, for predicting the risk of fatal and nonfatal cardiovascular disease in hypertensive groups.[1–6] The use of ABPM for untreated hypertensive patients, initially detected by clinic pressures, to define those with lower daytime and/or 24-hour average pressures has led to the concept of white-coat hypertension (WCH).[7] Pooled results from several prospective observational studies have shown that the likelihood for future stroke in WCH is nearly that of normal subjects for 5-year follow-up intervals.[8] WCH hypertension may also be related to a more favorable overall cardiovascular risk profile reflected by lower body mass index and favorable serum lipid patterns.[9] These findings support recommendations in current guidelines that ABPM be used in the management of hypertension.[10–12] ABPM is well tolerated by patients in primary care practices who consider the information provided to be helpful for their management.[13] Additional recognition of the value of ABPM has been the approval for reimbursement by the Center for Medicare and Medicaid Services of the United States (CMS).

When ABPM became available, it was suggested that this technology might be a cost-effective method if used as secondary screening for hypertension.[14] This suggestion was based on estimates or best guesses as to the cost of ABPM, the current cost of antihypertensive treatment, the risk of not treating those with WCH, and other factors.[15] During the past 15 years, several advances and changes have provided information that is highly relevant to the calculation of the cost-effectiveness for implementing ABPM into a system of care for those who are hypertensive after initial clinic screening. First, the relationships between ambulatory pressures and clinic pressures for hypertensive patients have become better defined with regard to the prediction of mortality and morbidity.[4–6,8] Second, transition rates for the incidence of new hypertension in those with WCH can be more accurately estimated.[16] Third, in the United States, the charges for ABPM are somewhat fixed by Centers for Medicare and Medicaid Services policies and are relatively low. Costs for treatment of hypertension can be estimated from various sources, including those from managed care organizations.[17] This new information has prompted a reassessment of ABPM for cost-effectiveness when used to confirm the diagnosis of hypertension.

Methods

Model for Calculation of Cost-Effectiveness

A model for calculating the costs of management for hypertension that includes or excludes the use of ABPM to detect sustained hypertension has been updated from an earlier version.[15] This model

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From the Mount Sinai School of Medicine, Englewood Hospital and Medical Center, Englewood, NJ.

Correspondence to Lawrence R Krakoff, Department of Medicine, Englewood Hospital and Medical Center, 350 Engle St, Englewood NJ 07631. E-mail Lawrence.Krakoff@ehmc.com

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takes into account the following elements: (1) the prevalence of WCH during initial screening; (2) the cost of ABPM; (3) the cost of treatment for hypertension; (4) estimates of the annual incidence of new hypertension during follow-up; and (5) an estimate of annual loss to follow-up and treatment.

The overall prevalence of WCH in those with recently detected hypertension has been in the range of 15% to 20% for younger populations and somewhat higher for older groups. Gender and duration of suspected hypertension may also modify the prevalence of WCH. For this analysis, a 20% prevalence of WCH was chosen for most analyses. However, the effect of varying prevalence of WCH from 15% to 25% was also evaluated. This is consistent with current recommendations that the diagnosis of WCH be based on either a daytime pressure <135/85 mm Hg or 24-hour pressures <130/80 mm Hg.[12]

The cost for ABPM in the United States can now be given because of the setting of prices for this procedure by the CMS. Current procedural terminology (CPT) codes have been assigned to the procedure. The range of prices set by CMS varies within the United States from $56 to $122 for 92 localities. The average price listed is $74 (95% CI, $72 to $76). The source for these prices is the Centers for Medicare and Medicaid Services (available online at http://www.cms.hhs.gov/physicians/mpfsapp). For the calculations used in our analysis, the average figure of $75 was used as the cost of ABPM.

The annual cost for treatment for hypertension for a group of patients is a composite of costs for physician visits, diagnostic tests, and medications. The cost for medications needed to control blood pressure will vary with the choice of drugs.[18] Higher overall costs for treatment needed to control hypertension are found for the first year of treatment with lower costs during subsequent years.[17,18] A survey from 1 large managed care organization reported that costs were as follows: first year of treatment, ≈$950; second year, ≈$575; third year and after, ≈$420, which resulted in a 5 year total of ≈$2900 per patient or $580 per treatment-year.[17] These amounts are remarkably similar to costs for treatment calculated from a randomized trial when a β blocker, angiotensin-converting enzyme inhibitor, or calcium blocker were used as initial treatment.[18] However, the cost of treatment was 30% to 40% lower if a diuretic was used as the initial treatment. A more recent report has calculated that guideline-based treatment (using diuretics as a base) would reduce the cost of treatment by as much as 40% for a large medical practice compared with current prescribing patterns.[19] In this presentation, the estimated costs for the treatment of hypertension used the lower or minimum costs for medication as if guideline-based prescribing were the usual pattern, as follows: first year, $570; second year, $345; and third to fifth year, $252. Thus, the 5-year total cost of treatment for an individual patient is $1671, for an average annual cost per patient of $334.

Estimates for the incidence of new hypertension among previously nonhypertensive subjects, using only clinic methods, have been assessed in the Framingham study[20–22] and in the Women's Health Initiative.[23] The annual incidence of new hypertension for women, with an average age of 45 years and followed for nearly 8 years, is strongly related to baseline pressure. Those with high normal pressure at baseline have a 4% to 7% annual incidence of new hypertension. In this study, baseline C-reactive protein levels added independently and to a small extent to the prediction of future hypertension.[23] In the Framingham population, 10- to 25-year estimates of new hypertension, based on screening at 2-year intervals, have varied from ≈1% to 2% at baseline for those with optimal pressure and 35 to 55 years of age to ≈15% for those 65 to 94 years of age with high normal pressures at baseline.[22] There are no comparable, large longitudinal studies for incidence of hypertension using ABPM or home blood pressures in community-based populations. However, 2 small series studied by serial measurements of ambulatory pressure suggest rates of new sustained hypertension among those with WCH at baseline, which vary from a high of 13% annually[24] to lower rates of 3% to 4% annually.[16] For this analysis, the estimated annual incidence of new hypertension, based on repeated ABPM for those with WCH, was varied from 5% to 20%.

The estimate of annual dropout or loss to follow-up used in this analysis is 5% for all of the groups and is a conservative one. Although very high rates of retention in treatment have been observed in some clinical trials, such as the Antihypertensive and Lipid-Lowering Treatment to Prevent Heart Attack Trial,[25] lower retention rates have also been observed in practice-based studies.[26] It is likely that dropout rates in nonresearch settings, that is, usual clinical practice, are far higher than 5%, but additional surveys are needed to establish this estimate.

In summary, the model begins with 1000 subjects, initially labeled as hypertensive, based on screening using office or clinic pressures. The baseline prevalence of WCH is varied from 15% to 25%, and the incidence of new confirmed hypertension, after initial assessment, is varied from 5% to 20%. Calculations for these groups are made over a 5 year period for the following: (1) number of WCH subjects; (2) number of new confirmed hypertensive subjects who will be treated during follow-up; (3) treatment years; (4) costs for treatment; and (5) costs for use of ABPM initially and for annual follow-up.

Results

The effect of a management strategy on the number of patients to be treated for hypertension over a 5-year period with a baseline prevalence of WCH of 20% is shown in Figure 1. Over the 5-year interval, there is convergence of the groups, an effect of the accumulation of new confirmed hypertensive subjects from the pool of those with WCH in previous years and the 5% loss rate for all of the groups. This pattern indicates that using ABPM for the annual reassessment of WCH would delay treatment for a small fraction, but most of those would eventually be detected and treated within 5 years as their pressures increase with age. Figure 2 displays the number of WCH subjects and new established hypertensive subjects over the 5-year interval that would be expected if the baseline prevalence of WCH is 20%. A high annual incidence of new confirmed hypertension (20%) will result in fewer WCH subjects remaining for repeat ABPM. In contrast, for a low incidence of confirmed hypertension (5%), there will be more WCH subjects to be retested.

Figure 3 displays the total years of antihypertensive treatment over 5 years for the same groups displayed in Figure 1. These are a group without use of ABPM and groups with a baseline prevalence of WCH of 20% and annual incidence of new hypertension varying from 5% to 20%.

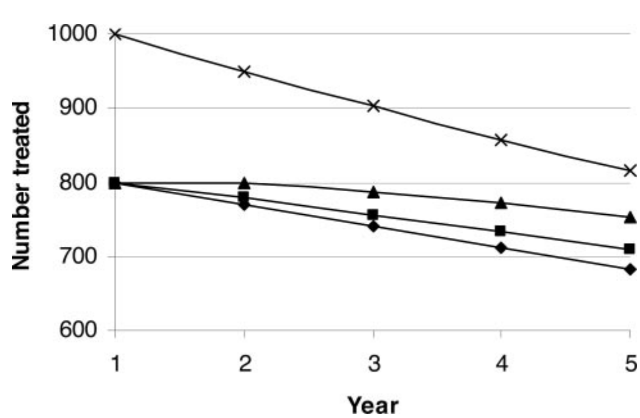

Figure 1. Number of patients treated for hypertension each year for 5 years. Based on 1000 patients for each group at the start and initial 20% prevalence of WCH. Symbols for groups are: ×, no ABPM; ♦, ABPM used with 5% incidence of new hypertension; ■, ABPM used with 10% incidence of new hypertension; and ▲, ABPM used with 20% incidence of new hypertension.

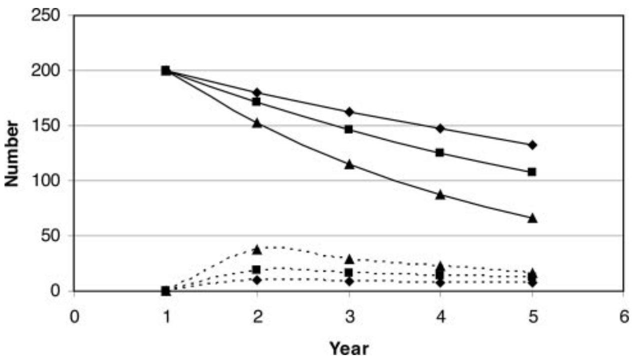

Figure 2. Number of patients with WCH (top solid lines) and new confirmed hypertensives (bottom dashed lines) at the start and over 5 years of follow-up using ABPM annually. ◆, 5% incidence of new hypertension; ■, 10% incidence of new hypertension; ▲, 20% incidence of new hypertension.

Table 1 displays the estimated costs for treatment and for testing (ABPM) for the 4 groups described in Figure 3. All of the groups who are screened initially and during annual follow-up for WCH have lower costs for treatment and total costs over the 5 years compared with the group that was not screened with ABPM. The lowest cost for the 5-year period occurs when the annual incidence of new hypertension is low (5%). This is because of a much higher annual cost of treatment compared with the much lower cost of screening. When more hypertensive subjects would be detected because of a higher annual incidence of hypertension (20%>10%>5%), the overall costs for treatment increases relative to the lower costs for testing, because fewer WCH subjects would remain. Thus, the calculated fractions of costs for testing by ABPM of the total costs are in the range of 6% to 10%.

Table 2 compares the effect of varying the initial prevalence of WCH from 15% to 25% on the total cost of testing and treatment over 5 years using the minimum for treatment costs. Compared with the cost for treatment without using ABPM, $1 546 494, the reductions in costs vary from the minimum of $45 322 to a maximum of $210 024, resulting in savings of 3% to 14%, respectively. However, if treatment costs are higher for the frequent use of calcium channel blockers or angiotensin-converting enzyme inhibitors as the initial treatment,[17] the savings for the ABPM strategy to detect WCH will range from $141 363 to $438 984.

Table 3 compares the effect of varying the initial prevalence of WCH from 15% to 25% on the number of treatment-years over the 5-year interval. If ABPM is not used, the calculated number of treatment-years is 4524. The reduction in treatment-years achieved through use of ABPM would vary from 10% to 23%.

The cost per treatment-year was calculated for each condition in Table 3 as the "break-even" cost if ABPM were used compared with the nonuse of ABPM and is shown in Table 4. If nonuse of ABPM results in 4524 treatment-years and use of ABPM for a group with an initial prevalence of WCH of 20% and an annual incidence of new hypertension of 10% (3779 treatment-years), then $156 per year per patient would be the amount at which the 2 strategies would have the same cost. The range of break-even costs per year of treatment varies from a maximum of $214 when the prevalence of WCH is 15% and annual incidence of new hypertension is 20% to a minimum of $130 when the prevalence of WCH is 25% and the annual incidence of new hypertension is 5%. These estimates suggest that the ABPM strategy will be cost saving in relation to the current annual cost of treatment per patient of $334, given above.

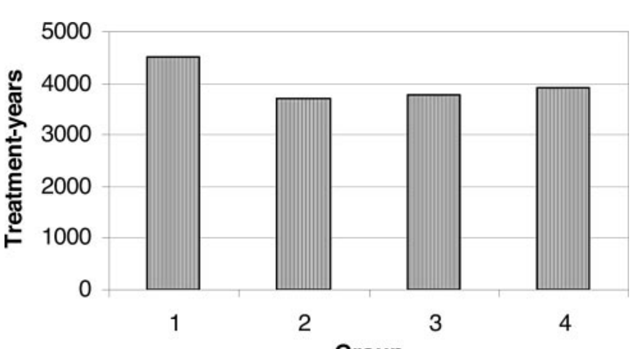

Figure 3. Number of treatment-years over a 5-year follow-up for: group 1, ABPM not used; group 2, ABPM used with 20% prevalence of WCH and 5% annual incidence of new hypertension; group 3, ABPM used with 20% prevalence of WCH and 10% annual incidence of new hypertension; group 4, ABPM used with 20% prevalence of WCH and 20% annual incidence of new hypertension.

Discussion

The results presented here indicate that use of ABPM to detect definite hypertension, initially and during follow-up of those initially identified as having WCH, may substantially reduce the cost of management for hypertension. The reduction in cost will be most evident when the prevalence of WCH is high but the incidence of new confirmed hypertension is low. If the initial prevalence of WCH is low but the annual incidence of new hypertension is high, the cost for the ABPM strategy will be relatively higher (because of testing) but remains a small fraction (<10%) of overall costs because of the high cost of annual treatment. Because the estimated cost for treatment was a minimum, using guideline-based prescribing, greater savings for the ABPM strategy will be achieved when higher priced medications are prescribed as is often the case.[17] A recent cost analysis from Australia is quite consistent with this report, despite a higher estimate for the cost of ABPM and a lower estimate for the cost of treatment than are used in this study.[27]

An ABPM strategy to detect WCH and delay treatment for hypertension will reduce treatment years and may result in sustained quality of life for those not receiving antihypertensive medication who do not need it.[28] The use of ABPM to select WCH might then be beneficial, even if the cost of treatment were lower. The annual treatment costs for the break-even calculations in Table 4 are well below the estimated range for annual cost from the guideline-based minimum ($334) to the higher annual figure ($580) that was found in current practice. Thus, an ABPM strategy may be beneficial clinically and cost saving financially.

The calculations used are based on currently available estimates for the prevalence of WCH in recently detected hypertensive groups and costs for ABPM and treatment of

TABLE 1. Estimated Effect of ABPM of Cost of Treatment Over 5 Years for 1000 Participants With Recently Discovered Clinic Hypertension

Group	Cost of Treatment	Cost of ABPM	Total Cost	Savings for ABPM Strategy	Percent of Non-ABPM Strategy
1: no ABPM	\$1 546 494	\$0	\$1 546 494	\$0	100%
2: ABPM 5% new	\$1 271 742	\$121 733	\$1 393 475	\$153 019	90%
3: ABPM 10% new	\$1 302 593	\$116 182	\$1 418 774	\$127 720	92%
4: ABPM 20% new	\$1 354 412	\$106 643	\$1 461 065	\$85 430	94%

Assumptions: 20% prevalence of WCT at baseline year. Three conversion rates from WCH to confirmed hypertension each subsequent year, 5%, 10%, and 20%. Costs of treatment, as above for first, second, and third+ years. Five percent loss rate for all groups. Calculation from baseline through 5 years of observation and treatment.

hypertension. The estimates for incidence of new hypertension in WCH are based on patterns for new clinic hypertension derived from population studies but consistent with small studies using ABPM with rates for new hypertension varying from <5% to nearly 15%.[16,24] By using a range of estimates for new hypertension during follow-up of the WCH subjects, the calculated results may apply to different groups where the expected prevalence of WCH and the incidence of new confirmed hypertension vary in relation to age, level of pressure, and pattern of cardiovascular risk factors.

The results presented in this report are based on the assumption that WCH will not be treated but that annual surveillance will use ABPM for those not treated. Physicians report that the results of ABPM are highly useful for their practices.[29] When ambulatory blood pressure is offered to primary care physicians as a support service, a very high percent accept advice to withhold drug treatment when average pressures are <135/85 mm Hg, resulting in a 20% reduction in treatment.[30] This pattern agrees well with the predicted reductions given in this presentation. Surveys of patients that have had ABPM indicate a high degree of satisfaction with the test, despite occasional discomfort. Most respondents recognize the value of the results for their management.[13,31]

The model used for these calculations does not include the use of ABPM to monitor treatment or treated patients with apparent refractory hypertension.[32] Using ABPM to monitor treatment might reduce the need for increased but ineffective medication.[33] One British study using an economic model predicts that the use of annual ABPM for treated patients would save the cost of treatment and need for visits but would result in a small net increase in annual cost of about £10 per patient.[34] In the United States, CMS policies fail to include treated hypertensives as eligible for reimbursement in the use of ABPM. It is not known whether other insurance plans will assist in payment.

ABPM of those with normal clinic pressures has exposed a small and variable fraction with hypertension, "reversed white coat" or "masked" hypertension. These patients may have greater target organ damage than those with ambulatory normal pressures[35] and seem to have morbidity and mortality that is more like established hypertension than WCH.[36] The prevalence of masked hypertension within the normotensive population is not yet fully established in different populations but may be far lower than the prevalence of established hypertension in those with clinic hypertension.[37] Screening of large normotensive groups by ABPM to yield a small fraction for drug treatment is likely to be very costly, so there is the need to develop accurate selection criteria for the use of ABPM in clinic normotension for efficient detection of masked hypertension.[38,39]

Recently published guidelines for the management of hypertension recognize the role of ABPM for the detection of WCH in the initial assessment of selected patients.[10,11,40] For those found to have WCH, long-term surveillance using ABPM has been recommended,[12,40] but no specific strategies have been fully explored. The results presented here provide a rationale for the use of annual ABPM to search for WCH in recent clinic hypertension as the basis for initial diagnosis and subsequent surveillance. It is predicted that overall cost of

TABLE 2. Relationships Between Prevalence of WCH at Baseline and Total Cost of Management (Tests Plus Treatment) Over 5 Years for Varying Annual Incidence of New Hypertension

WCH Prevalence	New Hypertension 5%	New Hypertension 10%	New Hypertension 20%
15%	\$1 450 480	\$1 469 454	\$1 501 172
	94%	95%	97%
20%	\$1 393 475	\$1 418 774	\$1 461 065
	90%	92%	94%
25%	\$1 336 470	\$1 368 094	%1 420 957
	86%	88%	92%

Percents shown are fraction of costs for use of ABPM compared with nonuse of ABPM.

TABLE 3. Relationships Between Prevalence of WCH at Baseline and Total Years of Treatment Over 5 Years for Varying Incidence of New Confirmed Hypertension

WCH Prevalence	New Hypertension 5%	New Hypertension 10%	New Hypertension 20%
15%	3908	3965	4063
	86%	88%	90%
20%	3703	3779	3909
	82%	83%	86%
25%	3498	3592	3755
	77%	79%	83%

Percents shown are fraction of treatment-years compared with nonuse of ABPM.

TABLE 4. Break-Even Annual Cost of Management for Hypertension Related to Use of ABPM, Based on Varying Initial Prevalence of WCH and Estimated Annual Incidence of New Confirmed Hypertension

Prevalence Of WCH %	Annual Incidence of New HT %	Costs for ABPM	Treatment Years	Break-Even Annual Cost of Treatment
15	5	$110 050	3908	$178
15	10	$105 886	3965	$189
15	20	$98 740	4063	$214
20	5	$121 733	3703	$148
20	10	$116 182	3779	$156
20	20	$106 653	3909	$173
25	5	$133 416	3498	$130
25	10	$126 477	3592	$136
25	25	$114 566	3755	$149

treatment for hypertension and years of drug treatment will be reduced. Additional studies are much needed to explore these estimates in community practice.

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