Blood Pressure and the Electronic Health Record: A Work in Progress

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In this issue of the *Journal of the American Heart Association* (JAHA), Ayala Solares et al used data from linked primary care electronic health records (EHRs) in the United Kingdom to test whether multiple blood pressure (BP) measurements over time are better predictors of future cardiovascular disease (CVD) events and death than single current baseline BP measurements. The authors identified 80 964 men and women at the age of 50 years who had at least one systolic BP (SBP) recorded within 1 year of baseline, at least 10 years of registration with their clinic before baseline, and no prior CVD or antihypertensive or lipid-lowering prescriptions. Associations between past SBP and incident CVD, defined as first hospitalization for or death from coronary heart disease or stroke/transient ischemic attack. The major finding was that elevated past, baseline, and usual SBP measurements were separately and independently associated with increased incident CVD risk. The associations with CVD risk were stronger for past and usual SBP measurements (hazard ratio, 1.39–1.45) than for single current baseline SBP (hazard ratio, 1.18–1.30). The authors concluded that although extracting multiple prior SBP measurements from the EHRs yielded stronger associations with incident CVD than use of a single SBP recording, adding multiple prior SBP values to multivariate risk prediction models did not significantly improve risk prediction.

The failure to find improvement in risk prediction when including long-term exposure to prior BP is consistent with prior studies. Paige et al conducted a pooled analysis of 191 445 adults with no history of CVD from 38 longitudinal cohort studies to assess the benefit of including repeated measurements of SBP and cholesterol compared with single baseline measurements in predicting absolute 5-year risk of CVD. They demonstrated a modest 1% improvement in the specificity of risk prediction models when repeated measurements were included. Similarly, Paynter et al estimated usual SBP and cholesterol levels using repeated measurements over 3 years before baseline. When incorporated into risk prediction models, there was no statistically significant improvement in C-indexes compared with single baseline measurements. The growing availability of EHRs and self-monitoring tools will make repeated SBP measurements more accessible to the practicing clinician. However, the findings of Ayala Solares et al temper the expectation that these values by themselves will significantly improve the predicative performance of risk stratification tools.

While acknowledging the correlations between past and current SBP with CVD outcomes, it is important to recognize the inherent limitations of in-office BP measurement for diagnosing hypertension and predicting CVD risk. Out-of-office BP measurement is needed to identify BP patterns that cannot be detected with in-office BP measurement alone. These phenotypes, which include white coat hypertension (BP elevated in office, normal out of office) and masked hypertension (BP normal in office, elevated out of office), are highly prevalent and have different prognoses.

White coat hypertension has been reported in 19% to 30% of untreated hypertensive patients in recent studies. Whether white coat hypertension is associated with increased CVD and mortality remains a matter of debate. White coat hypertension has traditionally been considered benign, as early studies did not show differences in long-term CVD outcomes in patients with white coat hypertension compared with normotensive controls. However, more recent findings have raised concerns that people with white coat hypertension are at increased risk of developing sustained hypertension and resultant CVD events over time. If, in fact, white coat hypertension has a relatively benign prognosis, risk models using SBP based on EHRs would overestimate CVD risk in these patients, likely resulting in unnecessary treatment with antihypertensive therapy.

The opinions expressed in this article are not necessarily those of the editors or of the American Heart Association.

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In contrast, masked hypertension, which has been reported in 15% to 25% of untreated hypertensive patients in recent studies, has been associated with a 2-fold increased risk of CVD compared with normotension.\(^5\)\(^-\)\(^7\)\(^,\)\(^10\)\(^-\)\(^11\) Masked hypertension is not captured using in-office EHR data, and use of risk prediction tools guided by EHRs data would leave these high-risk patients untreated.\(^4\)\(^,\)\(^12\)

The study by Ayala Solares et al\(^1\) has several strengths. It is the first to compare past, current, and usual SBP values obtained from EHRs from primary care practices. It identified a large sample size of \(\approx 80\) 000 individuals at the age of 50 years, representative of the UK general population, using EHRs from the UK Clinical Practice Research Database. The UK Clinical Practice Research Database is one of the largest databases in the world, providing clinical information from \(\approx 7\%\) of primary care practices in the United Kingdom.\(^13\)\(^,\)\(^14\) The analysis was restricted to data from participants of a single age (50 years) at enrollment, thus eliminating confounding by age, which has a major effect on BP over time. Exclusion of data from people with prevalent CVD or use of antihypertensive medications also adds rigor to the analysis of BP over time. The EHRs in the UK Clinical Practice Research Database is linked to the National Health Service databases on mortality and hospitalizations, thus ensuring complete capture of clinical data and CVD outcomes. Data used in the analysis were obtained from practices that met research quality standards, and the quality and validity of diagnoses recorded in the UK Clinical Practice Research Database have been reported previously.\(^14\) The authors recognized that EHRs often lack important data about risk factors and confounding factors and accounted for this using a statistical computational method. Real-world risk prediction models were also used to make the results generalizable; and repeated SBP measurements, derived from EHRs, had long-term predictive value similar to repeated SBP measurements in research data sets.

It is important to recognize the deficiencies of in-office BP, the only form of BP measurement commonly reported in EHRs. In-office BP measurements often misdiagnose hypertension.\(^15\) Accordingly, the 2015 US Preventive Services Task Force recommended use of ambulatory BP monitoring to diagnose hypertension\(^16\); and more recent guidelines have reinforced the importance of out-of-office BP measurement, including both ambulatory BP monitoring and home or self measurement for both diagnosis of hypertension and monitoring treatment.\(^12\) Ambulatory BP monitoring and home BP measurements are superior to in-office readings in predicting CVD outcomes. However, use of ambulatory BP monitoring remains infrequent because of limited access, excessive cost, and concerns over the accuracy and benefits of testing.\(^18\) For these reasons, many clinicians rely on in-office BP measures recorded in EHRs for clinical decision making.

EHRs represent a vast repository of patient data that are easily accessible and can be used to improve patient care. Although the current study did not show significant improvement in risk prediction using repeated measurements of BP recorded in EHRs over single clinic BP measurements, it helps lay the groundwork for future integration of machine learning to assist in patient care. Digital programs are currently being used to aid in BP management. For example, Milani et al evaluated BP control in 156 patients with uncontrolled hypertension using a home-based BP program in which commercially available BP monitors transmitted recordings directly to EHRs.\(^19\) Patients then received medication titration and lifestyle recommendations on the basis of their home readings. A total of 71% of participants achieved target BP levels (versus 31% of matched controls). Incorporating machine learning algorithms with currently used telemedicine practices and EHRs represents an exciting new avenue that could potentially improve how hypertension is treated and controlled.

Disclosures

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