Editorial

APOL1 and Cardiovascular Disease
A Story in Evolution

Archna Bajaj, Katalin Susztak, Scott M. Damrauer

Observational studies have long established that African Americans have a higher risk for developing chronic kidney disease (CKD) with faster progression to end-stage renal disease compared with Americans not of African descent, independent of socioeconomic and traditional clinical risk factors.\(^1\)\(^-\)\(^3\) But it was not until 2010 that the genetic basis behind this association became more apparent when 2 separate genome-wide association studies identified DNA variants in the APOL1 gene that were strongly associated with kidney disease in blacks.\(^4\)\(^-\)\(^5\) The story of the APOL1 gene that emerged is a fascinating example of natural selection against infectious disease, and discovery of its link to renal, and possibly cardiovascular, diseases has opened a new field of questions.

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APOL1 encodes for apolipoprotein L-I, a component of dense high-density lipoprotein 3 particles.\(^6\) Circulating apolipoprotein L-I has the ability to lyse the parasite Trypanosoma brucei, which is found only in sub-Saharan Africa.\(^7\) Over time, 2 subspecies of T. brucei, T. brucei gambiense and T. brucei rhodesiense, evolved resistance by producing a protein that binds and neutralizes apolipoprotein L-I. Subsequently, 2 APOL1 variants (G1 and G2) emerged, producing apolipoprotein L-I with decreased affinity for the trypanosome protein, conferring resistance to African sleeping sickness in carriers of these alleles.\(^8\) Although being protected from 1 disease, however, blacks with the APOL1 variant alleles have been shown to be at increased risk for renal disease, as well as a faster progression to end-stage renal disease.\(^9\) Individuals that are homozygous for either variant, or compound heterozygotes, have been found to have a 10\(\times\) to 17\(\times\) higher odds for focal segmental glomerulosclerosis,\(^10\)\(^-\)\(^11\) a 7\(\times\) higher odds for hypertension-associated end-stage renal disease,\(^5\) and 29\(\times\) to 89\(\times\) higher odds for HIV-associated nephropathy.\(^10\)\(^,\)\(^11\) Because of the initial natural selection, the prevalence of these variants in the population is significant: \(\approx\)40% of blacks carry 1 risk allele whereas 10\% to 15\% carry 2 risk alleles.\(^5\)\(^,\)\(^12\)\(^,\)\(^13\)

APOL1 is broadly expressed, including in the kidney and vasculature.\(^14\) Although the mechanistic role of APOL1 variants in disease development has yet to be fully elucidated, recent work in mouse models has demonstrated that the expression of APOL1 risk alleles alters podocyte function and results in kidney disease.\(^15\)

Beyond the risk for kidney disease, African Americans are also disproportionately at greater risk for cardiovascular disease (CVD),\(^16\) prompting the question of whether or not APOL1 variants underlie this association as well. In this issue of ATVB, Chen et al\(^17\) report on the association between the APOL1 risk alleles and CVD outcomes in the AASK (African American Study of Kidney Disease and Hypertension), a well-characterized cohort of individuals with CKD attributed to hypertension. The study’s authors compared the 160 AASK participants with 2 APOL1 risk alleles (high-risk) with the 533 who had either 1 or no risk allele (low-risk). Using a broad composite definition of CVD, including cardiovascular death, myocardial infarction, cardiac revascularization, heart failure, and stroke, the authors failed to detect a significant difference in risk for CVD between the high- and low-risk groups in both unadjusted and adjusted models. Arguably, the study by Chen et al\(^17\) may have been underpowered to detect an association, and thus, a negative result is difficult to interpret. Based on 693 participants and 144 composite events during 12 years of follow-up, they had 80% power to detect a minimum hazard ratio of 1.85. Although this is within the range of some of the previously reported studies, the divergent nature of the published literature suggests that the true hazard ratio may in fact be below their level of detection. Nonetheless, these results contribute important additional data to our still evolving knowledge of the relationship between APOL1 and CVD.

Prior studies on the association of APOL1 variants and CVD outcomes have generated a field of conflicting data. In 2014, Ito et al\(^18\) demonstrated that among 1959 black participants in the Jackson Heart Study, individuals with 2 APOL1 high-risk alleles were at twice the risk of incident CVD when compared with those without any risk alleles. The authors then replicated this association in 749 participants of African ancestry and without baseline CKD in the Women’s Health Initiative. This was further bolstered by findings from Mukamal et al\(^19\) who showed that in >6000 blacks in the Cardiovascular Health Study, participants with high-risk APOL1 genotypes had an 80% greater risk of incident myocardial infarction as compared with those with zero or only 1 risk allele; similar results were also found for peripheral vascular disease, suggesting a broader association between APOL1 and atherosclerosis.

In contrast to these initial reports, and in keeping with the work by Chen et al\(^17\) presented in this issue, a 2015

From the Division of General Internal Medicine, Department of Medicine (A.B.), Renal Electrolyte and Hypertension Division, Department of Medicine (K.S.), Department of Genetics (K.S.), Division of Vascular Surgery, Department of Surgery (S.M.D.), University of Pennsylvania, Philadelphia; and Department of Surgery, Corporal Michael J. Crescenz Veterans Affairs Medical Center, Philadelphia, PA (S.M.D.). Correspondence to Scott M. Damrauer, MD, Division of Vascular Surgery, Department of Surgery, University of Pennsylvania, 3400 Spruce St, 4 Silverstein Pavilion, Philadelphia, PA 19104. E-mail scott.damrauer@uphs.upenn.edu

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study of 2571 black participants from the SPRINT (Systolic Blood Pressure Intervention Trial) failed to demonstrate an association between high-risk APOL1 genotypes and CVD, despite showing a strong association with CKD.20 Similarly, investigators with the ARIC study (Atherosclerosis Risk in Communities) found a strong association between the high-risk APOL1 genotype and end-stage renal disease but failed to demonstrate any association with incident CVD in 3676 black participants.21

The discovery of the association of APOL1 variants with CKD was an exciting start to a story that is still unfolding. The question remains as to whether there is a link between APOL1 risk genotypes and CVD and if so, if it is distinct from a pathway to CVD driven by impairment in renal function (Figure). The results reported by Chen et al17 alone do not offer a definitive answer but rather provide one more piece to the puzzle. Given the wealth of data available, a meta-analysis of the existing literature offers a path forward to clarifying the true association between APOL1 and CVD. One of the challenges of assessing the present collection of studies, and in contemplating a meta-analysis, however, is the heterogeneity of outcomes used to define CVD and the range of underlying pathophysiological processes these represent; almost every published study has used a different composite CVD definition. Accordingly, future studies that evaluate APOL1 risk genotypes will need to carefully define outcomes. Electronic health records–based cohorts that allow for detailed phenotyping at a population scale represent a second pathway to elucidating the relationship between APOL1 and CVD. Such cohorts will have the sample sizes large enough to provide the necessary statistical power to detect, or not, associations between APOL1 genotypes and CVD outcomes, which are likely smaller than those seen with renal pathologies; both the current Veterans Affairs Million Veteran Program22 and the developing National Institute of Health’s All of Us Research Program23 will be key resources in this area. Discovering the pathways in which APOL1 connects to renal disease and CVD may guide the development of future therapies, preventive measures, and precision medicine in the high-risk black population.

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References


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