

Arrhythmias and the Cardiovascular-Kidney-Metabolic Continuum

Pierantonio Russo, MD¹, Brent Wright, RN, Dr PH²

¹EVERSANA Data & Analytics, Overland Park, Kansas, USA

²iRhythm Technologies, San Francisco, California, USA

Citation: Pierantonio Russo, Brent Wright. Arrhythmias and the Cardiovascular-Kidney-Metabolic Continuum. *Ann Med Res Pub Health*. 2026;5(2):1-7.

Received Date: 25 September, 2026; **Accepted Date:** 28 September, 2026; **Published Date:** 29 September, 2026

***Corresponding author:** Pierantonio Russo, MD, EVERSANA 7500 W 110th Street, Overland Park, KS 66210, USA, USA

Copyright: © Pierantonio Russo, Open Access 2026. This article, published in *Ann Med Res Pub Health* (AMRPH) (Attribution 4.0 International), as described by <http://creativecommons.org/licenses/by/4.0/>

ABSTRACT

The American Heart Association's cardiovascular-kidney-metabolic (CKM) framework, now codified in the 2026 AHA/ACC/ADA/ASN clinical practice guideline, describes a staged progression from excess adiposity to clinical cardiovascular disease. Within that architecture, atrial fibrillation appears only as a Stage 4 outcome. A growing body of national real-world evidence suggests this placement is incomplete. In cohorts of several million U.S. adults followed through administrative claims, major arrhythmias emerged at every CKM stage, rose steeply with stage progression, frequently preceded the diagnosis of chronic kidney disease, and, when they appeared after the onset of subclinical cardiovascular disease, marked a subgroup with substantially higher near-term risk of major adverse cardiovascular events. This editorial reviews that evidence in the context of the AHA/ACC guidance on CKM syndrome and argues that a documented major arrhythmia should be treated as a signpost of accelerating CKM progression and proposes four practical steps: stage-informed rhythm assessment, integration of arrhythmia status into CKM risk stratification, bidirectional kidney and rhythm surveillance, and prospective trials that test whether earlier detection changes outcomes. The observational nature of the supporting data and the limits of claims-based ascertainment are acknowledged; the case is for hypothesis-driven surveillance research, not for population screening.

Keywords: Cardiovascular-kidney-metabolic syndrome; Atrial fibrillation, Chronic kidney disease, Obesity, Real-world evidence

THE FRAMEWORK AND THE MISSING DIMENSION

In 2023 the American Heart Association formalized cardiovascular-kidney-metabolic (CKM) syndrome as a single, staged disorder: Stage 0 (no risk factors), Stage 1 (excess or dysfunctional adiposity), Stage 2 (metabolic risk factors or chronic kidney disease [CKD]), Stage 3 (subclinical cardiovascular disease or very high-risk CKD), and Stage 4 (clinical cardiovascular disease).¹ The companion PREVENT equations added kidney function and metabolic health

to absolute-risk estimation,² and in June 2026 the AHA, ACC, ADA and ASN issued the first joint clinical practice guideline for the prevention, detection, evaluation and management of CKM syndrome.³ This is a genuine conceptual advance. It replaces organ-by-organ care with a trajectory, and it tells clinicians where on that trajectory a patient stands.

Yet the trajectory, as drawn, is silent about cardiac rhythm until its last step. Atrial fibrillation (AF) enters the CKM staging figure only as one of the Stage 4 clinical events, alongside coronary heart disease, heart failure, stroke and peripheral artery disease.³ The guideline's AF section appropriately notes that overweight/obesity, hypertension, type 2 diabetes and CKD all increase AF risk and that lifestyle, weight, glycemic and blood-pressure management are the tools of prevention in Stages 1 to 3, deferring diagnosis and management to the 2023 ACC/AHA/ACCP/HRS AF guideline.⁴ Neither document offers is guidance on when, or in whom, rhythm should be assessed as CKM disease advances. There is no recommendation on electrocardiography or ambulatory rhythm monitoring in Stages 1 to 3. Arrhythmia is treated as a destination.

The argument of this editorial is that arrhythmia is better understood as a signpost. Major arrhythmias, and AF above all, arise from the same substrate the CKM framework describes, appear well before Stage 4 by the framework's own definitions, and identify patients whose progression toward major adverse cardiovascular events (MACE) is accelerating. If that is true, rhythm belongs inside the staging logic, not appended to its end.

WHY THE SUBSTRATE PREDICTS THE RHYTHM

The mechanistic case is not new. The Framingham Heart Study reported a roughly 4% increase in AF risk per unit of body-mass index, mediated in large part by left atrial enlargement.⁵ The Niigata study showed that metabolic syndrome as a cluster, not only its components, raised incident AF.⁶ In the Atherosclerosis Risk in Communities cohort, declining estimated glomerular filtration rate and albuminuria were each independently associated with incident AF, with a graded relationship across CKD stages,⁷ and in the Chronic Renal Insufficiency Cohort, new-onset AF in adults with CKD was followed by markedly higher rates of heart failure, myocardial infarction, stroke and death.⁸ Contemporary reviews describe the pathways in detail: epicardial and atrial adiposity, diastolic dysfunction, neurohormonal and inflammatory activation, autonomic imbalance, and structural and electrical atrial remodeling.^{9,10}

The 2023 AF guideline already encodes this biology in its own staging. Its Stage 1, "at risk for AF," is populated by obesity, hypertension, diabetes, sleep apnea and other modifiable exposures; its Stage 2, "pre-AF," is defined by the structural and electrical findings those exposures produce.⁵ The AF guideline's Stage 1 and the CKM guideline's Stages 1 and 2 describe the same patients. The two frameworks share a substrate but not a rhythm-assessment strategy.

WHAT NATIONAL REAL-WORLD COHORTS SHOW

Over the past two years our group has examined arrhythmia onset across the CKM continuum in U.S. national claims databases covering roughly 300 million lives. The findings are observational and claims-based, with the limitations discussed below, but their scale and internal consistency make them difficult to ignore. The principal results are summarized in Table 1.

Arrhythmia rises with CKM stage. In 3.38 million adults entering the continuum with obesity or overweight and no other CKM risk factor, any arrhythmia was recorded in 6.3% during Stage 1, 9.3% after progression to Stage 2 and 12.5% after progression to Stage 3.¹¹ In the full longitudinal analysis, in which CKM stage was modeled as a time-varying exposure, major arrhythmia incidence rose from 2.12 to 3.85 to 13.15 events per 1,000 person-years across Stages 1, 2 and 3, the median time from stage entry to first major arrhythmia shortened from 528 to 440 to 179 days, and the adjusted hazard for major arrhythmia was 1.58 (95% CI 1.54–1.62) in Stage 2 and 2.83 (95% CI 2.52–3.18) in Stage 3 relative to Stage 1 after adjustment for age, sex, payer, index year, health-care utilization and prior cardiology contact or ECG/ambulatory monitoring.¹² AF accounted for just over half of major arrhythmias at every stage.

Arrhythmia is not only an older adult's problem. Among patients with a major arrhythmia during Stage 1, 41% were aged 18 to 34 years; among those with a major arrhythmia in Stage 3, 42% were 65 or older.¹³ Early-onset obesity therefore carries an arrhythmic signal in a population that no age-based screening threshold would capture.

Kidney disease is an inflection point. Of 3.5 million adults with obesity and no baseline CKM risk factors, 26,478 progressed to CKD without intervening cardiac risk factors; 4% of these developed a major arrhythmia, 65% of them AF, within a median of four months of CKD onset, and 70% of those events clustered in CKD Stage 3.¹⁴ The relationship runs in both directions. In 8.5 million adults with CKD Stages 1 to 4, an arrhythmia, predominantly AF, was documented before the CKD diagnosis in 58% and on the same day in a further 14%, and 94% of those with a preceding AF carried at least one metabolic comorbidity.¹⁵ In adults with type 2 diabetes who developed CKD, 21% went on to a major arrhythmia; where the arrhythmia followed CKD, 17% experienced MACE, with a median arrhythmia-to-MACE interval of three days.¹⁶

Diabetes and obesity are a gateway. Among 8.17 million adults with coexisting type 2 diabetes and obesity and no prior AF, 7.8% developed AF over follow-up (1.89 per 100 patient-years), with cumulative incidence reaching 12.9% at seven years; post-AF mortality was independently associated with CKD (HR 2.14) and heart failure (HR 2.20).¹⁷ In the same population, AF and heart failure emerged within months of each other regardless of which came first (median 221 to 250 days), and the sequence heart failure-then-AF carried the lowest survival (Russo et al., 2026b). Earlier work in type 2 diabetes documented the downstream cost: arrhythmia was associated with higher emergency visits, hospitalizations and total cost of care in a matched cohort of more than 213,000 pairs.¹⁸

Arrhythmia after Stage 3 marks imminent risk. Among patients who reached Stage 3, MACE followed a subsequent major arrhythmia at a median of 65 days and AF at a median of 49 days.¹⁹ In the adjusted analysis, the 12-month MACE risk was 39.0% among Stage 3 patients with a post-Stage-3 major arrhythmia versus 10.5% among those without, an adjusted hazard ratio of 3.37 (95% CI 2.84–3.99), and roughly 70% of arrhythmia-to-MACE transitions occurred within six months. For these patients, the arrhythmia was not the end of the trajectory. It was the last warning before it.

Table 1 Arrhythmia onset across the cardiovascular-kidney-metabolic continuum: summary of national real-world cohorts

Population (source)	Design and data	Key finding
3.38 M adults with obesity/overweight, no other CKM risk factor (Russo et al., 2025a; unpublished full analysis)	Symphony Dataverse, 2018–2024; CKM stage as time-varying exposure; Cox models	Any arrhythmia 6.3% → 9.3% → 12.5% across Stages 1–3; major arrhythmia 2.12 → 3.85 → 13.15 per 1,000 PY; aHR 1.58 (Stage 2), 2.83 (Stage 3); post-Stage-3 major arrhythmia → MACE aHR 3.37; 12-month MACE 39.0% vs 10.5%
3.5 M adults with obesity, subset progressing to CKD (Russo et al., 2025b)	Symphony, 2018–2024; longitudinal follow-up after CKD onset	26,478 progressed to CKD; 4% developed major arrhythmia within median 4 months (65% AF); 70% of events in CKD Stage 3
8.5 M adults with CKD Stages 1–4 (Russo et al., 2025c)	EVERSANA open claims, 2018–2024; timing of arrhythmia vs CKD index	Arrhythmia preceded CKD in 58%, same day 14%; AF 75–83% of arrhythmias; 94% with ≥1 metabolic comorbidity
3.2 M adults with T2D who developed CKD (Russo et al., 2025d)	Symphony, 2018–2024; poster, ADA 2025	21% developed major arrhythmia; where arrhythmia followed CKD, 17% had MACE at median 3 days
8.17 M adults with T2D and obesity, no prior AF (Russo et al., 2026a)	Symphony, 2018–2025; Kaplan–Meier and Cox	AF incidence 1.89/100 PY; cumulative 12.9% at 84 months; post-AF mortality HR: CKD 2.14, HF 2.20, age ≥75 2.84
205 K adults with T2D and obesity developing both AF and HF (Russo et al., 2026b)	Symphony, 2018–2025; temporal sequencing	AF→HF 34%, same day 31%, HF→AF 35%; median interval 221–250 days; HF→AF lowest survival
T2D adults with vs without arrhythmia, 213,226 matched pairs (Russo et al., 2025e)	MarketScan 2006–2023 and Symphony 2018–2023; matched cohort	Higher ED visits, hospitalizations, readmissions and total cost with arrhythmia; lower utilization among those with ambulatory ECG monitoring

aHR = adjusted hazard ratio; AF = atrial fibrillation; CKD = chronic kidney disease; CKM = cardiovascular-kidney-metabolic; ED = emergency department; HF = heart failure; MACE = major adverse cardiovascular events; PY = person-years; T2D = type 2 diabetes. All cohorts are retrospective, claims-based and observational; CKM stages were inferred from diagnosis and procedure codes.

READING THE SIGNAL CORRECTLY

Three cautions are needed before these observations are translated into practice. First, all of the cohorts are administrative. CKM stage was inferred from diagnosis and procedure codes rather than measured body-mass index, estimated glomerular filtration rate, albuminuria or imaging, and obesity in particular is under-coded in claims. Second, arrhythmia ascertainment requires a billed encounter; subclinical and paroxysmal events are missed, and detection rises with contact intensity. The stage gradient persisted after adjustment for utilization, cardiology visits

and prior ECG or ambulatory monitoring, and most first arrhythmia diagnoses occurred in outpatient rather than acute settings, which argues against pure surveillance artifact, but it cannot exclude it. Third, and most important, association is not benefit. That an arrhythmia forecasts MACE does not prove that finding it earlier prevents MACE.

The AF screening literature is the appropriate corrective. The U.S. Preventive Services Task Force found insufficient evidence in 2022 to recommend for or against screening asymptomatic adults.²⁰ STROKESTOP, which used intermittent single-lead ECG in 75- and 76-year-olds, showed a small net clinical benefit,²¹ whereas LOOP, which used implantable recorders in older adults with stroke risk factors, tripled AF detection and anticoagulation without reducing stroke.²² Wearable patch and smartwatch studies demonstrated that detection at scale is feasible,²³ but not that it improves hard outcomes. The lesson is that detection strategies must be targeted at populations in which the arrhythmia is both prevalent and prognostically consequential and must be paired with an intervention capable of altering the course. The CKM continuum may be precisely such a population, and the intervention in question is not only anticoagulation but the full CKM toolkit: weight management, glycemic and blood-pressure control, kidney-protective therapy and, for AF specifically, the risk-factor modification the 2023 guideline recommends as a Class 1 element of care.

OUR PROPOSAL

We believe the current evidence supports four steps, listed from the simplest to implement to the most demanding.

Obtain a baseline ECG at the two CKM transitions where arrhythmia incidence rises. In the national cohort, major arrhythmia incidence increased from 2.1 to 3.9 events per 1,000 person-years when patients moved from Stage 1 to Stage 2, and to 13.2 when they reached Stage 3. We therefore propose a 12-lead ECG (a) when a patient with obesity first acquires a metabolic risk factor or CKD (entry into Stage 2), and (b) when subclinical cardiovascular disease or CKD Stage 4 to 5 is identified (entry into Stage 3). The test is inexpensive and already part of routine care; what changes is that it is triggered by CKM stage rather than by symptoms alone.

Ambulatory ECG monitoring should be considered for patients with symptoms, in line with current guidance, but in patients with several CKM risk factors clinicians should act promptly even on milder or less specific symptoms than they would in a patient without them.

Treat a documented major arrhythmia as a risk enhancer within CKM staging. The 2026 guideline already intensifies therapy for Stage 2 and Stage 3 patients who carry additional markers of risk, such as albuminuria or a high PREVENT score. We propose that a major arrhythmia recorded in a Stage 2 or Stage 3 patient be handled the same way: it should be listed with the other risk enhancers when the stage is assigned, and it should prompt the same intensification of weight, glycemic, blood-pressure and kidney-protective management.

Link kidney surveillance and rhythm surveillance in both directions. In the national CKD cohort, an arrhythmia was documented before the CKD diagnosis in 58% of patients. The two conditions therefore serve as early warnings

for each other. When AF is newly detected in a patient with obesity, diabetes or hypertension, estimated glomerular filtration rate and urine albumin-to-creatinine ratio should be measured. When CKD is newly diagnosed in the same kind of patient, a rhythm assessment should follow, including with ambulatory ECG monitoring.

Test stage-informed surveillance in a prospective trial.

We propose a pragmatic trial in which CKM Stage 2 and Stage 3 patients are randomized either to protocolized rhythm assessment (steps 1 to 3 above) combined with guideline-directed CKM management, or to usual care, with MACE, heart-failure hospitalization and CKD progression as endpoints. Preliminary claims analyses using entropy balancing have found that symptomatic adults with cardiometabolic risk who received ambulatory monitoring before their arrhythmia diagnosis had lower subsequent emergency-department and hospital use than comparable unmonitored patients. Those findings are hypothesis-generating; the trial is what would confirm or refute them.

CONCLUSION

The CKM framework succeeded because it gave clinicians a map. The map is incomplete where rhythm is concerned. In the largest real-world cohorts yet assembled, major arrhythmias appear at every stage of CKM syndrome, become more frequent and arrive sooner as stage advances, preceding kidney disease as often as they follow it, and, once subclinical cardiovascular disease is present, identify the patients in whom a major event is weeks away. None of this proves that surveillance saves lives, but all of it argues that arrhythmia should be read as a signpost of accelerating disease rather than as its final destination. The next revision of the CKM guidance should say where on the trajectory we should look for it.

Conflict of interest

PR is an employee of EVERSANA. The cited real-world studies were funded by iRhythm Technologies. No funding was received for the writing of this editorial.

Ethical approval

Not applicable. The cited analyses used retrospective, de-identified administrative claims data and did not require institutional review board approval.

REFERENCES

1. Ndumele CE, Rangaswami J, Chow SL, et al. Cardiovascular-kidney-metabolic health: a presidential advisory from the American Heart Association. *Circulation*. 2023;148(20):1606–1635.
2. Ndumele CE, Neeland IJ, Tuttle KR, et al. A synopsis of the evidence for the science and clinical management of cardiovascular-kidney-metabolic (CKM) syndrome: a scientific statement from the American heart association. *Circulation*. 2023;148(20):1636–1664.
3. Khan SS, Coresh J, Pencina MJ, et al. Novel prediction equations for absolute risk assessment of total cardiovascular disease incorporating cardiovascular-kidney-metabolic health: a scientific statement from the American Heart Association. *Circulation*. 2023;148(24):1982–2004.
4. Ndumele CE, Rodriguez F, Dixon DL, et al. 2026 AHA/ACC/ADA/ASN guideline for the prevention, detection, evaluation, and management of cardiovascular-kidney-metabolic syndrome: a report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. *J Am Coll Cardiol*. 2026;87(22S):e1889–e2007.

5. Joglar JA, Chung MK, Armbruster AL, et al. 2023 ACC/AHA/ACCP/HRS guideline for the diagnosis and management of atrial fibrillation: a report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. *J Am Coll Cardiol*. 2024;83(1):109–279.
6. Wang TJ, Parise H, Levy D, et al. Obesity and the risk of new-onset atrial fibrillation. *JAMA*. 2004;292(20):2471–2477.
7. Watanabe H, Tanabe N, Watanabe T, et al. Metabolic syndrome and risk of development of atrial fibrillation: the Niigata preventive medicine study. *Circulation*. 2008;117(10):1255–1260.
8. Alonso A, Lopez FL, Matsushita K, et al. Chronic kidney disease is associated with the incidence of atrial fibrillation: the Atherosclerosis Risk in Communities (ARIC) study. *Circulation*. 2011;123(25):2946–2953.
9. Bansal N, Xie D, Sha D, et al. Cardiovascular events after new-onset atrial fibrillation in adults with CKD: results from the Chronic Renal Insufficiency Cohort (CRIC) study. *J Am Soc Nephrol*. 2018;29(12):2859–2869.
10. Lavie CJ, Pandey A, Lau DH, Alpert MA, Sanders P. Obesity and atrial fibrillation prevalence, pathogenesis, and prognosis: effects of weight loss and exercise. *J Am Coll Cardiol*. 2017;70(16):2022–2035.
11. Kornej J, Börschel CS, Benjamin EJ, Schnabel RB. Epidemiology of atrial fibrillation in the 21st century: novel methods and new insights. *Circ Res*. 2020;127(1):4–20.
12. Russo P, Nathan R, Poh J, et al. Abstract 4361830: Onset of arrhythmias in the CKM continuum: real-world insights from a national cohort. *Circulation*. 2025;152(Suppl 3):A4361830.
13. Russo P, Nathan R, Poh J, et al. Abstract 4361892: CKD and CKM syndrome: accelerated progression to arrhythmias in a national cohort. *Circulation*. 2025;152(Suppl 3):A4361892.
14. Russo P, Nathan R, Poh J, et al. Abstract 4361945: Arrhythmias as early predictors of CKD: real-world evidence from a national cardio-kidney-metabolic cohort. *Circulation*. 2025;152(Suppl 3):A4361945.
15. Russo P, Nathan R, Jha V, et al. Incidence and timing of major arrhythmias in T2D and CKD: a real-world analysis. Poster presented at: American Diabetes Association 85th Scientific Sessions; June 2025; Chicago, IL.
16. Russo P, Nathan R, Jie W, et al. 2960-LB: Diabetes and obesity as a gateway to atrial fibrillation: incidence, burden, and predictors among eight million adults. *Diabetes*. 2026;75(Suppl 1):2960-LB.
17. Russo P, Nathan R, Jie W, et al. 2959-LB: Temporal sequencing of heart failure and atrial fibrillation in patients with obesity and type 2 diabetes: a real-world evidence study. *Diabetes*. 2026;75(Suppl 1):2959-LB.
18. Russo P, Nathan R, Pfeiffer D, et al. Clinical and economic burden of cardiac arrhythmias in patients with type 2 diabetes. *J Health Med Econ*. 2025;11(1):151.
19. Davidson KW, Barry MJ, Mangione CM, et al; US Preventive Services Task Force. Screening for atrial fibrillation: US Preventive Services Task Force recommendation statement. *JAMA*. 2022;327(4):360–367.
20. Sennelsberg E, Friberg L, Frykman V, et al. Clinical outcomes in systematic screening for atrial fibrillation (STROKESTOP): a multicentre, parallel group, unmasked, randomised controlled trial. *Lancet*. 2021;398(10310):1498–1506.
21. Svendsen JH, Diederichsen SZ, Højberg S, et al. Implantable loop recorder detection of atrial fibrillation to prevent stroke (The LOOP Study): a randomised controlled trial. *Lancet*. 2021;398(10310):1507–1516.
22. Steinhubl SR, Waalen J, Edwards AM, et al. Effect of a home-based wearable continuous ECG monitoring patch on detection of undiagnosed atrial fibrillation: the mSToPS randomized clinical trial. *JAMA*. 2018;320(2):146–155.
23. Perez MV, Mahaffey KW, Hedlin H, et al. Large-scale assessment of a smartwatch to identify atrial fibrillation. *N Engl J Med*. 2019;381(20):1909–1917.