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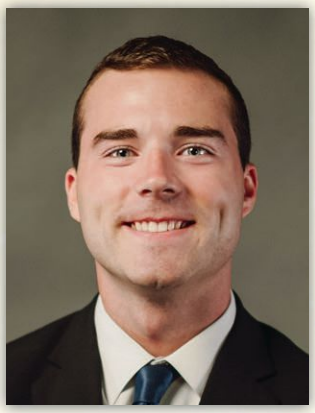
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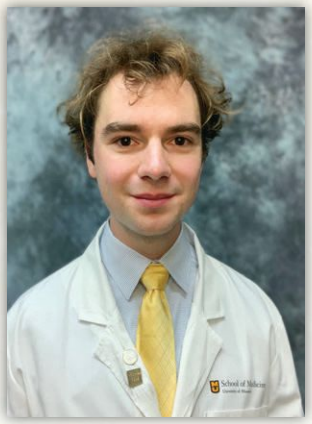
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# Missouri Medicine

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# Inequity in Physician Compensation Is Killing Private Practice

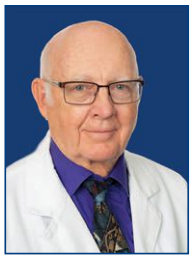
*by John C. Hagan III, MD*

## Introduction

American healthcare has changed so profoundly in the last three to four decades that it is all but unrecognizable to those of us spending our careers in private practice. In my opinion, the root causes are not that complex. Foremost among them is the unconscionable disparity between the remuneration received by hospital-employed physicians and that of their counterparts in private practice for the same service or procedure.

This is abetted by an accelerated decline in physician Medicare reimbursement, the vast political power of the American Hospital Association (AHA), and the waning membership and political influence of the American Medical Association (AMA). Finally, the percentage of all physicians committed to political and profession advocacy is regrettably, and inexcusably, low.

When this dinosaur (me) went into community ophthalmology in 1975, private practice was the mode of 70-80% of US physicians. That figure is now



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less than 50% and falling like the proverbial rock.[1] Moreover 80-90% of present physicians-in-training wish to avoid the risks of private practice and plan to be employed physicians.

This biased reimbursement discrepancy not only fuels the ongoing trend of physicians leaving private practice for hospital employment[2] but also raises concerns about the increasing financialization of "not-for-profit" hospitals. These sham non-profits often operate as profit-driven entities, allocating vast resources to inflated administrative staffs and salaries rather than prioritizing patient care.[3] This not only diverts resources away from direct patient care but also raises questions about the true purpose of these institutions.

A long-time champion of private practice and a critic of non-profit hospitals was our superb, recently deceased, contributing editor Arthur K. Gale, MD.[1,2]

## The Legal Framework: The Root of All Evil

The roots of this unequal compensation can be traced back to changes in reimbursement policies and legal frameworks that govern healthcare payments. The Balanced Budget Act of 1997 sought to control Medicare spending and introduced a myriad of reforms, including the creation of the Medicare Physician Fee Schedule. This fee schedule set payment rates for a wide range of physician services. Specifically, and unfortunately, it differentiated between hospital-based providers and those in private practice. This has had an unexpectedly drastic effect on how physicians are reimbursed for the same services based on their practice settings. This differentiation was primarily aimed at controlling Medicare spending while ensuring access to care. Did it work? Not at all!

A key rationale for providing hospitals with greater reimbursement was the belief that they operate with higher overhead costs and provide a significant amount of 'free' indigent care. This narrative, championed by AHA and the nation's hospitals, perpetuates the disparity between hospital and private practice compensation. The issue is further compounded by the influence of powerful hospital lobby groups, which advocate for policies that bolster institutional reimbursement rates, thereby entrenching the financial advantages of hospital-employed physicians over their private practice counterparts.

## Comparative Analysis of Medicare Services: Hospital vs. Private Practice

The cherished trump card for hospitals is the platinum-plated "facility fee." Hospital physicians are paid about 80% more than their private practice peers for the same services. This creates untenable differentials. In 2021, hospital physicians were paid on the average $114,000 more than private practice physicians for similar services. "The payment difference varied by specialty. The payment gap was $63,000 for primary care doctors, $178,000 for medical specialists and $150,000 for surgeons. Moreover, the study found the differential grew over time. From 2010-2016, the average difference between hospital outpatient and private practice payments grew from 80% higher to 99% higher."[4]

Among specialties, not all medical or surgical areas are equally attractive to hospitals. Institutions tend to favor specialties that primarily provide inpatient care or those that generate extensive charges for services like laboratory tests, x-rays, and medications. Specialties that function mainly in outpatient settings, such as ophthalmology and dermatology, are often less appealing to hospitals. This is due to their lower potential for generating facility fees and additional ancillary revenue that hospitals always seek to maximize. Hospitals—like Jerry Maquire—say: "Show me the money!"

Recently, another pernicious trend has emerged: the aggressive acquisition of private practices by Private Equity (PE) firms, especially in fields like ophthalmology. These for-profit organizations are purchasing practices at an alarming rate, motivating–make that compelling–their physician employees to prioritize profit maximization. This drive for profitability often results in higher costs to patients and a reduction in the quality of care,[5] as PE firms aim to extract as much profit as possible to prepare these practices for a lucrative resale.

Another factor promoting mid- and late-career physicians selling out to PE is, unlike in the past, they no longer have a viable exit plan. Younger physicians are increasingly unwilling to "buy-in" to the practices stock and assets given the declining revenues, diminishing salaries and rising costs of private practice. This is a scenario familiar to this author. When I left solo private practice in 2000, my accountant told me it would be September each year before I cleared enough profit to pay myself a salary.

## The Impact: A Shift Towards Hospital Employment

Given the substantial reimbursement advantages available to hospital-employed physicians, the trend of physicians abandoning private practice in favor of hospital employment continues to grow. According to data[6] from the AMA, the percentage of physicians in private practice decreased from approximately 57% in 2000 to just 42% by 2024. This dramatic shift illustrates the pressing financial realities faced by private practice physicians.

This migration is not merely a personal choice but a survival mechanism in a highly competitive marketplace. As compensation nears untenability for private practices, rising administrative burdens and regulatory compliance further complicate the ability to thrive independently. A 2021 survey reported that nearly 50% of private practicing physicians indicated they would be open to leaving private practice entirely if financial conditions did not improve.[6] The stark reality is the chance of financial improvement is slim to none.

This shift towards hospital employment raises ethical questions about physician autonomy and patient care. Many physicians who transition to hospital employment report a loss of independence and control over their practices, which can inadvertently impact doctor-patient relationships. They are usually compelled to refer within their group. There may be pressure to generate more profits by ordering unnecessary tests and doing unneeded procedures and surgery. Monthly billing quotas may be imposed. Patients may find themselves navigating healthcare systems that prioritize institutional objectives over individualized care. Hospital pressures lead to a more corporatized, assembly-line, 15-minutes/patient encounter approach to medicine. This also affects scope of practice. Which will be more attractive to patient: 15 minutes with a physician specialist they have waited four months to see or 45 minutes to an hour with a sympathetic, listening physician assistant or nurse practitioner they waited 12-24 hours to see?

## Possible Solutions to Preserve Private Practice

To rectify this situation, health policy stakeholders must engage in a comprehensive reevaluation of the current payment structures governing medical reimbursement, fostering an environment where all healthcare providers are fairly compensated irrespective of their practice setting. Doing so not only preserves the integrity of American healthcare but also ensures that patient care remains at the forefront of medical governance. The time for reform is now, as equity in physician compensation is critical to achieving an effective and sustainable healthcare system for all. This is a pat answer that would make Pollyana proud. It is not my own.

This is my editorial so here is my opinion. It is wholly inconceivable that hospitals and the AHA would agree to equal pay for equal work. Facility fees are like the air they breathe, not going to stop either. Except for the small number of physicians in concierge medicine or those with such fabulous reputations they can run cash-only practices (think cosmetic surgery), private practice is headed in the direction of the dinosaurs. Private practice is dead man walking. I don't think of myself as a pessimist but an experienced, insightful realist.

## Conclusion

The stark disparity between hospital-employed physicians and privately practicing ones demands urgent attention and systemic change. Policies that were initially intended to standardize care and control costs have inadvertently created inequities that undermine both physician independence and patient care. As more physicians continue to abandon private practice in favor of hospital employment, the once diverse landscape of American healthcare is approaching a homogenization that will jeopardize accessible, personalized care. Sad beyond words.

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MM




# Medicare Advantage: What Physicians Need to Know

*by Ed Weisbart, MD, Kip Sullivan, JD & Mark Krasnoff, MD*

When she was 82 years old, Pat started to experience episodes of chest pain and shortness of breath. Her internist in Florida referred her to a local cardiologist, who diagnosed her with hypertrophic cardiomyopathy (HCM). Her brother had died at age 85 from the same diagnosis.

At the time, there were no clinical centers in Florida specializing in HCM. Her family in St. Louis found that Washington University had a team with this focus and flew her up to Missouri. She underwent alcohol ablation of the hypertrophic area of her septum, spent a few days recovering as an inpatient without complications, and soon returned to Florida. Over the next decade she had good quality of life and ultimately passed away at age 94.

Despite traveling out of state, she never had to go through a prior authorization process, never had a copay or deductible, and never received a surprise medical bill. Pat had Traditional Medicare and paid a monthly premium for a Plan F Medigap supplemental policy. This story may have been quite different had she instead signed up for a Medicare Advantage plan. Far too many people don't really understand the implications of this choice, or even that they're making a choice.

## Origin of Medicare Advantage

There was a time when doctors and patients didn't need to understand Medicare Advantage (MA) because it didn't exist. When Medicare was implemented in 1966, it was a relatively simple program. Original Medicare, now often called Traditional Medicare (TM), consisted of Part A, which paid for hospital services, and Part B, which paid for physician services. There was no Part C, the program that today finances the MA program, and no Part D, which pays insurance companies to cover prescription drugs.



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Americans age 65 or older are automatically enrolled in Part A if they or their spouse has worked and paid Medicare taxes for at least ten years. Enrollment in Part B is not automatic; beneficiaries can enroll in Part B if they pay a premium.

The relative simplicity of Medicare was due to three features: (1) direct payment of providers (no insurance companies or other risk-bearing corporations sat between Medicare and providers); (2) beneficiaries' freedom to choose their doctor and hospital; and (3) monitoring for fraud and abuse, but little if any interference by the administering agency with the practice of medicine. Those three features of original Medicare have been changed beyond recognition over the last half-century.

The transformation of these three features was driven by increased health care spending in the US in both the private and public sectors.

Congress took the first step to address rising Medicare expenditures in 1972.[1] The Social Security Amendments of 1972 (P.L. 92–603) authorized the Social Security Administration to contract with a new form of insurance called the "Health Maintenance Organization" (HMO). The HMO label was invented in February 1970 by a Minnesota physician named Paul Ellwood at a meeting with three members of the Nixon administration. Ellwood argued that health care inflation was due to doctors ordering unnecessary services, and this was happening routinely because of the way doctors were paid: the fee-for-service (FFS) method. Given that diagnosis, it is no surprise that Ellwood thought the solution was to turn the FFS incentive upside down by paying doctors through "capitation," shifting insurance risk onto doctors. Capitated doctors ran the risk of losing money if they continued to order the allegedly unnecessary services.

For capitation to have the most impact on medical decisions, patients had to be limited in their choice of doctors. Limiting patient access to one capitated doctor, or a group of them, would be possible only if the limitation were written into a patient's insurance contract. HMOs were insurance companies that were paid a premium like any other insurance company (for some reason these premiums also came to be called "capitation" payments) that limited a Medicare beneficiary's choice of doctor and paid doctors by capitation instead of fee-for-service.

Ellwood and the early HMO proponents never addressed an obvious question: Is it possible for HMOs to reduce unnecessary services by an amount large enough to offset HMO overhead (administrative costs plus profit) without harming patients? Three decades later, Bruce Vladeck, HCFA's administrator from 1993 to 1997, and Barbara Cooper posed the challenge facing Medicare HMOs as follows: "[C]apitated plans – with administrative expenditures in the range of 8-25 percent – have to incur medical expenditures 10-25 percent less … just to break even. In most markets, capitated plans cannot attract enrollees unless they offer additional benefits, which also costs money… ."[2]

## The Medicare Advantage Trap

Pat's health outcomes may have been quite different if she had chosen to avoid paying the premiums for Medigap and instead enrolled in Medicare Advantage, where narrow networks, prior authorizations, and out-of-pocket expenses frequently delay and often deny access to the healthcare chosen by patients with their physicians.

If her care had been denied or delayed, and she had then decided to disenroll from her MA plan, she would have faced a trap. She would have needed to buy a Medigap plan to protect herself from the large out-of-pocket costs to which TM beneficiaries are otherwise exposed. People in Traditional Medicare without a Medigap plan are exposed to unlimited personal financial risk. In 2026, Part A requires a $1,716 deductible for each hospitalization period and Part B requires a 20% coinsurance for all outpatient services,[3] with no upper limit. Although the most common Medigap plans nearly eliminate such personal expenses, for many people Medigap isn't a realistic option. This has been called "The Gap Trap."[4]

Many people incorrectly assume that the ACA's protections against insurers pricing based on pre-existing conditions applies to all health insurance. Similar protections apply to Medigap during the first six months after enrollment in Medicare Part B or the first twelve months in MA. However, after six to twelve months, with some state variations, Medigap insurers are allowed to individually underwrite applicants and decline to sell someone a policy which effectively destroys the guarantee of being able to purchase Medigap at the same price as the rest of the community.

Had Pat been in an MA plan instead of TM with Medigap, by the time she would have wanted to leave MA, return to TM, and purchase Medigap she would have been saddled with the kind of diagnosis (hypertrophic cardiomyopathy) that would have ensured a Medigap policy to be priced beyond reach – if any insurer were willing to sell her a policy at any price.

Medicare Advantage's protections against initial out-of-pocket costs for relatively health enrollees, along with

the highly promoted promises of additional benefits, accounts for its rapidly growing capture of the Medicare population. However, these features of MA come at a significant cost to the Medicare program, patients, and ultimately taxpayers.

## Causes of Medicare Advantage Overpayments

By the 1990s, it was clear HMOs typically were not capable of reducing medical expenditures sufficient to offset their overhead costs without harming patients. Private health insurance companies can make money off of Medicare only if they are paid far more to insure a beneficiary than the beneficiary would have cost had they remained in TM. Publicly funded MA insurers depend on the delay and often outright denial of medically necessary services. In the 1980s and 1990s, multiple studies appeared demonstrating that Medicare HMOs were enrolling beneficiaries who were on average much healthier and therefore less costly to insure than beneficiaries who remained in TM (a phenomenon known as "favorable selection"), but Medicare was paying the HMOs as if they enrolled beneficiaries in average health.[5] Keeping the introductory clause implies sicker MA patients no longer disenroll and switch to TM (they do), and MA plans no longer benefit when sick enrollees return to TM (they do).The Health Care Financing Administration (HCFA), the agency created in 1977 to administer Medicare and Medicaid, did not ignore the overpayments caused by favorable selection. The staff and HCFA's consultants attempted to measure the "risk" that HMO enrollees would need health care, compare it to the risk of beneficiaries who stayed in Traditional Medicare, and modify HMO payments accordingly, a process known as "risk adjustment." But the measures HCFA used for risk measurement —age, sex, nursing home status, and enrollment in Medicaid—were so crude that risk adjustment was essentially worthless. In a 1994 article for Health Affairs, economist Joseph Newhouse characterized "risk adjustment technology" as "primitive."[6] Analysts generally agreed the problem with HCFA's risk adjuster was that it did not include direct measures of health, namely patient diagnoses.

In the Balanced Budget Act of 1997, Congress allowed insurance companies of all stripes (not just HMOs) to participate in Medicare and instructed HCFA to add diagnoses to their risk adjuster. HCFA, renamed the Centers for Medicare and Medicaid Services (CMS) in 2001, phased in a diagnosis-based risk adjuster between 2000 and 2006. But the new risk adjuster, known as the Hierarchical Condition Categories (HCC) model, added very little predictive value to the old demographic-based model.

To make matters worse, the introduction of the HCC created the opportunity for MA plans to increase their overpayments by "upcoding." Upcoding refers to adding diagnoses to patient medical records that are accurate but irrelevant to the true cost of care, or just plain false.

## Today's MA Plans Make Money Off Both Favorable Selection and Upcoding

The Medicare Payment Advisory Commission (MedPAC), an advisory body created by Congress, estimates in its annual reports to Congress the total cost of the overpayments to Medicare Advantage plans. Their latest estimate is that the plans were paid 20 percent more for each enrollee than the enrollee would have cost had they remained in TM, roughly half due to favorable selection uncorrected by CMS's risk adjuster and half caused by upcoding, and that these overpayments added $84 billion to Medicare expenditures.[7] Unfortunately, overpayments to Medicare Advantage plans are boosted as well by other features of CMS's method of calculating capitation payments to the plans in addition to favorable selection and upcoding. In a paper published in October 2022 by Physicians for a National Health Program (the three of us were among the authors), we estimated that when all causes of overpayments are taken into account the overpayments may be as high as 35 percent, or about $150 billion in 2025.[8] Note that these estimates do not take into account the additional administrative costs Medicare Advantage plans impose on clinicians and hospitals.

## Are We Getting Our Money's Worth?

People unfamiliar with MA might reasonably think that the vast overpayments to the MA plans means they offer insurance superior to that offered by TM. The evidence does not support that inference.

Determining the quality of MA compared with that of TM is more complex than determining the relative costs of the two programs. Cost relies on a single measure, namely, dollars spent. Quality, on the other hand, must be assessed with multiple measures, including breadth of coverage (services covered and exposure to out-of-pocket payments), quality of care, and availability of providers. This multiplicity-of-measures problem is aggravated by incomplete and inaccurate data from the plans. Consequently, all three of those categories of quality measurement are very difficult to evaluate.

The least difficult of the measures is breadth of coverage. It is the measure most aggressively promoted by MA plans in their marketing. Federal law and regulations permit MA plans to use a portion of their overpayments to cover services beyond those covered by TM such as pharmacy, dental, vision, and hearing services. In a chapter in its June 2025 report to Congress entitled "Supplemental benefits in Medicare Advantage," MedPAC reviewed the sparse research on supplemental benefits and concluded, "Altogether, our review of numerous data sources pertaining to MA supplemental benefits reveals a fundamental lack of transparency about how often enrollees use the benefits and plans' spending for the benefits."[9] One of the few studies that sought to determine the extent to which supplemental services are used by MA enrollees concluded that a large fraction of MA enrollees did not use the extra hearing and vision benefits during the period 2017 to 2021, and during that same period MA plans spent just 10 percent of their overpayments on all supplemental services (not counting the cost of reducing out-of-pocket payments and Part B premiums). Although individual MA plans varied widely, the analysis demonstrated median reductions in out-of-pocket spending by MA beneficiaries (as compared to those in TM) of $23 per dental visit, $20 per pair of eyeglasses, and $22 per Durable Medical Equipment purchase (largely driven by hearing aids).[10]

To sum up, the MA overpayments finance some services not covered by TM and reduce some out-of-pocket costs, but total expenditures on these benefits is difficult to determine, many enrollees do not use these benefits, and funneling tax dollars through MA plans is an inequitable method of financing supplemental benefits.[11]

The second category of quality measures—quality of care—is even more confounded than measures of coverage. In 2019, MedPAC declared CMS's five-star-rating report card for MA plans to be so inaccurate it should be replaced.[12] In 2025 MedPAC characterized the literature on MA quality as "inconclusive" due to "wide heterogeneity in terms of study populations, metrics evaluated, and data sources used."[13]

There are at least two major obstacles to accurate measurement of the quality of health insurance companies: health insurance is a bundled product (it covers thousands of services), and risk-adjustment is needed for most services—but risk adjustment is crude. Because health insurance covers so many services, creating a single accurate measure of quality, or even a few that purport to be all encompassing, is impossible; on the other hand, a measure limited to just a few services (for example, the percent of diabetic enrollees who receive an annual eye exam, kidney function test, and HbA1c test) represents a microscopic and unrepresentative slice of the universe of services typically covered by health insurance. Crude risk adjustment is another obstacle to accurate measurement of quality, just as it is for measurement of cost.

Access to health care constitutes a third category of plan quality measurements, along with coverage and quality of care. Access is affected by multiple variables, including narrow networks and "ghost networks" (networks that do not include the providers listed in network directories). In 2022, the average MA enrollee had access to half as many doctors as TM enrollees did, and 12 million MA enrollees were in networks that excluded 70 percent of the physicians in their county.[14,15]

Access problems caused by limited networks are often aggravated by inaccurate directories. According to MedPAC's June 2024 report, "inaccuracies are rampant."[16] The Office of Inspector General for the Department of Health and Human Services reported in 2025 that 55 percent of mental health professionals listed as in-network by MA plans were not available to the plan's enrollees.[17] CMS does very little to enforce network adequacy regulations.[18] According to MedPAC, "CMS has the authority to impose sanctions for noncompliance with network adequacy standards, but has never done so."[19]

Disputes between MA plans and providers also threaten access. According to a 2025 report from KFF, "Just this year, at least 38 hospital systems serving all or parts of 23 states have cut ties with at least 11 Advantage plans after failing to agree on payment and other issues, according to a review of news releases and press reports. Over the past three years, separations between Advantage plans and health systems have increased 66%... ."[20]

Aggressive use of prior authorization constitutes another barrier to access for MA enrollees. In a recent review of prior authorization in the Medicare program, Biniek et al. offered this contrast between MA and TM: "Virtually all enrollees in Medicare Advantage (99%) are required to obtain prior authorization for some services—most commonly, higher cost services, such as inpatient hospital stays, skilled nursing facility stays, and chemotherapy. This contrasts with Traditional Medicare, where only a limited set of services, including certain outpatient hospital services, non-emergency ambulance transport, and durable medical equipment, require prior authorization." According to the authors, the rate at which prior authorization is used is far higher in MA than TM – 1.7 per MA enrollee in 2024 versus 0.02 per TM enrollee. Utilization of prior authorization by MA plans has

accelerated dramatically, from 30 million authorizations in 2020 to 53 million in 2024.[21]

Prior authorization has several destructive effects. The worst, of course, is the impact on patients. Prior authorization often denies necessary services, and even when necessary services are eventually authorized, the delay can damage patient health. Prior authorization of cancer-related services, for example, extends the delay between diagnosis and treatment and causes higher post-surgical mortality rates.[22] Another side effect is long-lasting damage to physician morale.

## Conclusions and Recommendations

For several decades the evidence has demonstrated that the MA program is driving Medicare's costs up, not down, is at best failing to improve quality on balance, and is probably having a net destructive effect on quality. We propose that Congress eliminate the MA overpayments and use those funds to create a low out-of-pocket maximum in TM, as well as adding pharmacy, vision, hearing, and dental coverage to TM. Such a level playing field would more fairly reveal the preferences of Medicare beneficiaries.

Reducing the overpayments will not be simple. Repealing two of the minor sources of overpayment—the counter-productive "quality bonus" and ineffective subsidies for MA plans that operate in rural areas—is not complicated. But reducing the two most important sources of overpayment—favorable selection coupled with crude risk adjustment, and upcoding—is complex and will be difficult. Legislation authorizing reducing overpayments should recognize these problems and include a provision limiting how long CMS will have to determine to what extent the overpayments can be reduced and at what cost.

Beyond helping their patients navigate the important personal decision between Traditional Medicare and Medicare Advantage, physicians should take a leadership role in elevating these concerns within organized medicine and the broader community.

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**MM**



# A Food-First Prescription for Cognitive Longevity

*by Max Lugavere*

**The path to cognitive longevity is not found in the pharmacy; it begins on the plate.**

## Introduction

Dementia is now recognized as one of the fastest-growing chronic global health burdens, with prevalence projected to nearly triple by 2050, yet only a minority of cases are driven by fixed genetic causes.

The 2024 Lancet Commission on Dementia Prevention, Intervention, and Care now lists 14 modifiable risk factors that together account for an estimated 45% of the population-attributable risk.[1] Well-established contributors include obesity, hypertension, diabetes, depression, hearing loss, smoking, physical inactivity, social isolation, alcohol misuse, and air pollution. Newly added in the 2024 update include high LDL cholesterol and untreated vision loss. Importantly, many of these are diet-responsive.

However, this estimate is likely conservative, as it does not account for several emerging and biologically plausible contributors to cognitive decline. These include micronutrient deficiencies (for example, inadequate intake of B-vitamins, omega-3 fatty acids, and carotenoids) and the widespread use of anticholinergic medications, which have been linked in cohort studies to greater dementia risk.[2] Including these additional, modifiable factors would almost certainly raise the proportion of preventable cases.

This opens a window of opportunity: if clinicians can help patients modify the right exposures early enough, a substantial proportion of dementia cases may be prevented or substantially delayed. Because many of the biological processes underlying dementia begin decades before diagnosis, midlife represents a critical window for prevention.



Max Lugavere is a health and science journalist, filmmaker, and author whose work explores the intersection of nutrition, metabolism, and brain health. His reporting and commentary have appeared CNN, PBS, The Guardian, The New York Times, and Medscape. He co-authored the chapter "Prevention of Cognitive Decline" in The Handbook on the Neuropsychology of Aging and Dementia, Second Edition (Springer, 2019).

In this Perspective, I synthesize recent evidence, building on the framework of my 2018 book *Genius Foods*, to illustrate how food quality and composition can favorably shift multiple risk factors simultaneously. I argue that nutrient-dense, minimally processed diets provide a foundation for metabolic, vascular, and structural brain health and represent an under-utilized front line in dementia prevention.

## Why Food Matters

The adult brain represents only 2-3% of body weight yet consumes roughly 25% of resting energy. Its neurons rely on a continuous supply of glucose, amino acids, essential fatty acids, and micronutrients to sustain synaptic signaling and repair. Because neural membranes are rich in polyunsaturated fats (PUFA), especially docosahexaenoic acid (DHA), they are uniquely vulnerable to oxidation and inflammation. Consequently, diet influences nearly every pathway relevant to cognitive aging:

### *Vascular integrity*

Dietary sodium, potassium, magnesium, and polyphenols modulate endothelial function and blood pressure.

### *Glucose Homeostasis*

Diets high in ultra-processed foods promote obesity and peripheral insulin resistance, which have been linked to cerebral glucose hypometabolism; higher protein, minimally processed patterns enhance insulin sensitivity by promoting energy balance and the maintenance of skeletal muscle.

### *Mitochondrial Efficiency and Oxidative Stress*

Mitochondria generate reactive oxygen species; antioxidants (vitamin E, carotenoids, anthocyanins) and mitochondrial cofactors (creatine, carnitine) buffer this stress.

### *Neuroinflammation*

Dietary fats influence the balance between pro- and anti-inflammatory eicosanoids.

### *Synaptic Plasticity and Neurogenesis*

Amino acids and micronutrients such as choline, B-vitamins, zinc, and magnesium are required for neurotransmitter synthesis and neuronal membrane formation.

Viewed through this lens, foods that build, protect, and energize the brain form the core of an evidence-based neuro-protective pattern.

## Diet-Responsive Risk Factors

### *Obesity and Insulin Resistance*

Chronic neuroinflammation, endothelial dysfunction, and insulin resistance are all hallmarks of accelerated cognitive aging. Randomized trials such as PREDIMED demonstrate that Mediterranean-style diets comprised primarily of minimally processed foods lower inflammatory markers and improve vascular function without calorie restriction. Conversely, controlled feeding studies show that ultra-processed foods (UPFs) cause participants to overeat by approximately 500 kcal per day, leading to weight gain and metabolic impairment.[34]

Excess adiposity, particularly visceral and ectopic fat accumulation, is the primary driver of systemic insulin resistance (IR), a central feature of both metabolic and cognitive aging. In the brain, impaired insulin signaling disrupts neuronal glucose uptake, synaptic plasticity, and amyloid and tau metabolism. Preventing or reversing overfatness through improved diet quality is therefore one of the most effective strategies for restoring insulin sensitivity.

Epidemiologic data consistently link UPF consumption with cognitive decline and dementia. In a large prospective cohort, each 10% increase in UPFs predicted roughly 25% higher dementia risk; a 2024 meta-analysis of >860,000 adults confirmed a 44% greater risk among the highest consumers.[567] While residual confounding and reverse causation cannot be entirely excluded, the consistency of results across multiple longitudinal cohorts and dose-response trends strengthens the likelihood of a causal relationship.

Along with food processing level, the protein content of food is a major determinant of spontaneous energy intake.[8] Therefore, replacing highly processed foods with whole foods, and further emphasizing protein-rich foods, can enhance satiety and preserve lean mass, thereby improving energy balance, insulin sensitivity, vascular health, and cognitive function.

### *Hypertension*

SPRINT-MIND was a landmark clinical trial suggesting that intensive blood pressure lowering (< 120 systolic mmHg vs. 140) reduced the risk of mild cognitive impairment.[9] Cerebral perfusion depends on elastic, nitric-oxide-responsive vessels. Minimizing ultra-processed food consumption, the leading contributor of sodium in American diets, while emphasizing potassium- and magnesium-rich foods (fresh fruit, dark chocolate, salmon, beef, nuts and seeds), omega-3-rich fish (herring, sardines, mackerel, salmon), and nitrate-containing vegetables (spinach, arugula, beets) lower blood pressure and improve endothelial function.

A meta-analysis of 30 randomized controlled trials including more than 3,000 participants found that olive oil interventions significantly improved endothelial function while also reducing C-reactive protein and interleukin-6 concentrations.[10] In a large US cohort, consuming roughly half a tablespoon of olive oil daily was associated with a 28% lower risk of dementia-related mortality, independent of overall diet quality and ApoE4 status.[11] Likewise, both the DASH and Mediterranean dietary patterns reduce stroke and cognitive-impairment risk independent of medication use, underscoring the role of diet in vascular health.

### *Vision Loss*

The Lancet Commission's inclusion of untreated vision loss underscores the diet-brain connection. Diets rich in leafy greens and egg yolks containing plant pigments lutein and zeaxanthin raise macular-pigment optical density, which improves visual acuity and helps prevent age-related macular degeneration. Thus, supporting ocular health through carotenoid-rich foods may also mitigate a newly recognized dementia risk.

### *Depression*

Depression is a modifiable risk factor for dementia. The role of diet in depression is complex. Increasing evidence links UPFs to depression risk, however causality is likely bidirectional. Meta-analyses show that diets abundant in omega-3 fatty acids, magnesium, folate, creatine, B12, and polyphenols reduce depressive symptoms and oxidative stress. The SMILES trial demonstrated that a whole-food Mediterranean-style diet produced clinical remission in one-third of depressed patients (four times the remission rate of the group receiving standard care), further illustrating diet's influence on both mood and cognition.[12]

## Protecting Neurons from Oxidative Stress

Neuronal membranes are rich in PUFA that readily oxidize; without adequate antioxidant defenses, lipid peroxidation and mitochondrial injury accelerate neuronal aging. Diets abundant in colorful plant pigments provide crucial protection.

### *Carotenoids*

Along with the eyes, carotenoids such as lutein and zeaxanthin accumulate selectively in the brain, where they localize to neuronal membranes and protect against oxidative and inflammatory stress. These pigments—concentrated in avocado, egg yolks, pistachio nuts, and especially dark leafy greens—act as both antioxidants and modulators of membrane fluidity and intercellular signaling. In one longitudinal cohort, daily leafy-green consumption was associated with the cognitive equivalent of being 11 years younger.[13]

Higher circulating levels of lutein and zeaxanthin are associated with superior cognitive performance across multiple domains, including memory, executive function, and processing speed, as shown in large population-based cohorts such as The Irish Longitudinal Study on Aging.[14] Randomized, double-blind trials have demonstrated causal benefits: supplementation with lutein and zeaxanthin improved neural processing speed and visual-cognitive efficiency, and enhanced memory performance in healthy older adults with low baseline carotenoid levels.[15]

Neuropathological findings lend compelling support: a 2023 analysis published in the *Journal of Alzheimer's Disease* found that brain concentrations of lutein, zeaxanthin, and lycopene (a carotenoid concentrated in tomatoes and tomato products) in individuals with Alzheimer's disease were roughly half those measured in cognitively normal controls.[16]

### *Anthocyanins and Polyphenols*

Anthocyanins, responsible for the deep blue and purple hues of berries, red cabbage, and purple

sweet potatoes, enhance neuronal signaling and cerebral blood flow. Controlled studies demonstrate improvements in executive function and working memory following anthocyanin-rich berry interventions.[17] These compounds inhibit microglial activation and promote endothelial nitric-oxide release, supporting cerebral blood flow.

Polyphenols are a broad class of bioactive compounds found in foods like coffee, tea, dark leafy greens, herbs and spices, berries, and extra-virgin olive oil that help modulate the gut microbiota and reduce oxidative stress and inflammation.

### *Balancing Omega-3 and Omega-6 Fatty Acids*

Among dietary fats, the relative balance of omega-3 and omega-6 PUFA plays an important role in modulating inflammatory signaling within the brain. Experimental and translational evidence indicates that long-chain omega-3s, particularly DHA and EPA, give rise to specialized pro-resolving mediators that dampen microglial activation and promote resolution of neuroinflammation.[18] The modern Western diet, however, has shifted toward substantially higher intake of omega-6 linoleic acid (LA), largely from refined, bleached, and deodorized grain and seed oils (e.g. soybean and corn oil), which contain highly unsaturated fatty acids that can form lipid-oxidation products under high-heat cooking conditions.

LA-dominant seed oils reliably lower LDL cholesterol versus saturated fats, yet the long-term neurological consequences of chronically high LA intake remain uncertain. Because these fatty acids are highly unsaturated and are readily incorporated into neuronal membranes, further research is warranted to clarify their long-term neurological effects.

Experimental work (e.g., Taha et al.) shows that higher LA incorporation into brain phospholipids can shift endocannabinoid tone and increase oxidized LA metabolites (OXLAMS) with pro-inflammatory signaling, suggesting plausible neuronal effects.[19] Conversely, lowering dietary linoleic acid reduces OXLAMS in human plasma, which is elevated in Alzheimer's disease.[20] As a clinical proof-of-principle for targeting the LA/omega-3 axis, a randomized trial by Ramsden et al. found that lowering dietary LA while increasing omega-3s reduced migraine frequency and severity (an inflammatory pain disorder with overlapping neurovascular pathways) though cognitive outcomes were not assessed.[21] Together, these findings motivate trials directly testing LA reduction (with adequate omega-3 intake) on brain and cognitive endpoints.

DHA is also the principal structural omega-3 fat in neuronal membranes and synapses, and most Americans markedly underconsume it. Adequate dietary DHA supports membrane fluidity, neurotransmission, and neuroprotection throughout the lifespan. In the Framingham Offspring Study, individuals in the highest quintile of red-blood-cell DHA had a 49% lower risk of incident Alzheimer's disease than those in the lowest quintile.[22]

### *Vitamin E*

Vitamin E is the brain's principal lipid-soluble antioxidant. Adequate dietary intake, as opposed to supplementation alone, is associated with slower cognitive decline and lower Alzheimer's incidence in cohort studies.[23] However, in a randomized clinical trial, high-dose supplemental vitamin E (2000 IU/day) did slow functional decline in patients with established Alzheimer's disease.[24] Naturally vitamin E-rich foods (nuts, seeds, extra-virgin olive oil, avocados, and eggs) fit seamlessly within Mediterranean-style eating patterns.

Importantly, the physiological requirement for vitamin E rises with higher intake of PUFA, since it protects oxidation-prone fatty acids from peroxidation. In whole foods, this relationship is inherently balanced; PUFA-rich foods naturally co-deliver antioxidant tocopherols. However, industrially refined grain and seed oils are high in LA but relatively poor sources of vitamin E, creating a mismatch between PUFA load and antioxidant protection. This unaccounted-for vulnerability may help explain why higher dietary vitamin E is consistently associated with slower cognitive decline and lower Alzheimer's risk in observational studies, and why inadequate intake remains common (~90% of U.S. adults) despite high-PUFA consumption in the modern diet.

## Protein for the Aging Brain

Sarcopenia and frailty are increasingly recognized as cognitive-risk amplifiers. Skeletal muscle functions

as a metabolic and endocrine organ, serving as glucose disposal "sinks" while releasing myokines that regulate inflammatory and neuroplastic pathways affecting the brain. With age, anabolic resistance blunts muscle-protein synthesis, raising the threshold of dietary protein required per meal.

Emerging data suggest intakes of 1.2-1.6 g/kg/day, evenly distributed (0.4-0.6 g/kg/meal), better preserve lean mass, insulin sensitivity, and functional independence, all indirectly protecting cognition.[25] Protein adequacy also supports neurotransmitter production and cerebrovascular health. Combining protein-adequate diets with resistance training yields synergistic benefits, reducing both frailty and dementia risk.

Both short- and long-term studies show that protein-rich diets also help to prevent obesity by reducing hunger.[2627] Even protein enrichment of UPFs reduces overconsumption, thus indirectly supporting brain health.[28]

### Creatine, Meat/Fish, and Cognition

Creatine (synthesized from arginine, glycine, and methionine or obtained directly from meat and fish) serves as an intracellular energy buffer, recycling adenosine triphosphate (ATP) in tissues with high metabolic demand, including brain and muscle.

Cross-sectional studies show that higher dietary creatine intake, a surrogate for regular consumption of meat and fish, associates with better working memory and fluid intelligence in older adults.[29] Meta-analyses of supplementation trials reveal modest but consistent improvements in short-term memory, reasoning, and mental fatigue, particularly under sleep deprivation or hypoxic stress.[30] Emerging data even suggests supplemental creatine may provide therapeutic support in the setting of Alzheimer's disease.[31]

Mechanistically, creatine stabilizes neuronal energy homeostasis, limits excitotoxicity, and supports synaptic function. Because endogenous synthesis declines with age, maintaining adequate creatine through diet or supplementation may enhance brain resilience. Foods richest in creatine include beef, pork, salmon, and cod, underscoring the cognitive value of including unprocessed animal protein within an overall health-promoting pattern. From a UK Biobank cohort of over 5,400 participants, a higher intake of protein from animal sources relative to plant sources was linked to slower hippocampal atrophy on MRI, suggesting structural benefits of consuming animal protein that extend beyond muscle preservation.[32]

### Red Meat, LDL-C, and Brain Health

Epidemiologic findings on red meat and cognitive outcomes have been mixed. Some population studies report associations between higher total red-meat intake and greater dementia risk, while others, particularly those that distinguish processed from unprocessed meat, find no such relationship or even inverse associations when red meat is consumed as part of nutrient-dense, balanced diets. In the UK Biobank cohort of nearly 500,000 participants followed for eight years, each 50 grams per day of unprocessed red meat was associated with a 19% lower risk of all-cause dementia and a 30% lower risk of Alzheimer's disease, independent of ApoE4 status.[33]

Much of the apparent risk in aggregate analyses likely reflects confounding by overall diet quality and lifestyle, as higher red-meat consumption often coexists with lower intake of fruits, vegetables, and fish, as well as higher prevalence of smoking, obesity, sedentary behavior and lower socioeconomic status.

### LDL-Cholesterol as a Modifiable Risk

The 2024 Lancet Commission explicitly added high LDL-cholesterol to the list of modifiable dementia risks, reflecting evidence that atherosclerosis and cerebral small-vessel disease compromise perfusion and accelerate cognitive decline. Lipid management is therefore central to both cardiovascular and brain prevention strategies. However, many misconceptions exist about the role of individual food components, particularly red meat, in lipid management.

### Context: Where Saturated Fat Actually Comes From

US dietary surveillance shows that most of the saturated fat arises from mixed dishes (burgers, pizza, sandwiches), desserts, and dairy, not from unprocessed red meat consumed as a stand-alone food.[34] Thus, blaming lean beef or lamb for population-level dyslipidemia misrepresents actual

intake patterns. Further, Dhakal et al. showed that among high quality diets (Healthy Eating Index ≥ 80), red meat inclusion is not at odds with meeting a target saturated fat intake of 10% of daily calories.[35]

### *Beef and LDL in Controlled Trials*

Meta-analyses reveal that lean beef yields only small, often non-significant increases in LDL-C (≈ 2-3 mg/dL) without adverse changes in HDL-C, triglycerides, or apolipoprotein B and performs comparably to fish and poultry.[3637] In the Beef in an Optimal Lean Diet (BOLD) and BOLD+ studies, omnivorous diets containing four to six ounces of lean beef daily improved blood pressure and vascular compliance equivalently to DASH-style or vegetarian diets.[3839] A meta-analysis by O'Connor et al. found that total red meat consumption for up to 16 weeks did not affect changes in biomarkers of glycemic control or inflammation for adults free of, but at risk for, cardiometabolic disease.[40] Collectively, these findings indicate that within an otherwise high-quality diet, moderate lean beef intake has a neutral, if not favorable, cardiometabolic profile.

### *Nutrient Density of Red Meat*

Red meat provides a wide array of brain-critical nutrients difficult to attain elsewhere—creatine, vitamin B12, heme iron, zinc, choline, selenium, and carnitine—all vital for mitochondrial function, myelination, and neurotransmitter synthesis.

Notably, 100% grass-fed beef contains roughly three-fold more vitamin E compared to grain-finished beef, as well as meaningful levels of antioxidant phytonutrients such as polyphenols and carotenoids, as reviewed by van Vliet et al.[41] These compounds may help mitigate byproducts of high-heat cooking and confer modest vascular and neuronal benefits.

## A Holistic Approach to Lipid Management

For patients with elevated LDL-C, the priority should be reducing UPFs, confectionary foods, and isolated fat extracts (such as coconut oil, butter, and beef tallow) rather than eliminating unprocessed lean red meat. (Notably, dairy fat, apart from butter and butter derivatives, may have a neutral-to-beneficial impact on lipids including LDL.[42]) Increasing dietary fiber, particularly from vegetables, legumes, nuts, low-sugar fruits, and psyllium husk supplements, can further improve LDL particle clearance and support metabolic health. For overweight or obese individuals, achieving sustained fat loss should be a front-line strategy for improving lipid profiles and overall metabolic health. In addition, screening for and appropriately treating hypothyroidism is essential, as reduced thyroid function is a common and reversible cause of elevated LDL-C.

## Beyond Diet: Synergistic Lifestyle Pillars

No single intervention rivals the power of lifestyle synergy. Physical activity, especially resistance and aerobic exercise, enhances neurogenesis and insulin sensitivity, amplifying dietary benefits. Sleep consolidation supports glymphatic clearance of metabolic waste such as β-amyloid.

Addressing hearing and vision, now recognized modifiable factors, preserves sensory input critical to cognitive reserve. Social engagement and purpose reduce stress reactivity and inflammatory tone, while smoking cessation and moderation or elimination of alcohol protect cerebrovascular integrity. Medication review is also essential: minimizing chronic exposure to anticholinergic agents, which have been linked to increased dementia risk in large epidemiological studies, can substantially lower pharmacologic burden on cognition. Environmental exposures such as air pollution and endocrine-disrupting chemicals are emerging targets; reducing these where feasible complements nutritional prevention.

A truly preventive approach thus integrates diet, movement, sleep, and environment—a multidomain strategy consistent with the FINGER and MAPT clinical trials showing additive effects on cognitive preservation.[43]

## Clinical Takeaways and Implementation

### *Assess Individual Risk Profile*

Identify risk factors: blood pressure, A1c, obesity risk, LDL-C, vision status, mood, activity level.

### *Prescribe Dietary Pattern*

Emphasize nutrient-dense, minimally processed foods; liberal vegetables and fruits of varied pigment; adequate protein (≥ 1.2 g/kg/day); and encourage moderate use of extra-virgin olive oil as the primary kitchen oil.

### *Address LDL Pragmatically*

If overweight, encourage weight loss first. Increase dietary fiber if tolerated. Screen for hypothyroidism which can contribute to elevated LDL. Replace saturated-fat-dense mixed dishes, added fats/oils, and sweets before reducing lean meats and dairy.

### *Ensure Brain-Specific Nutrients*

Encourage carotenoid-rich produce, choline-rich eggs, anthocyanin-rich berries, vitamin E-rich nuts, and creatine-rich meats and fish.

### *Reinforce Lifestyle Pillars*

Pair diet with resistance training, restorative sleep, sensory-health maintenance, and social engagement.

### *Follow Up on Adherence and Biomarkers*

Track weight, BP, lipids, fasting glucose, homocysteine, and subjective cognition. Small, sustainable changes compound over years.

For busy clinicians, these principles can be summarized succinctly: eat real food, prioritize color and protein, move daily, sleep deeply, and stay connected.

## Conclusion

Emerging data suggest that a substantial proportion of sporadic, late-onset Alzheimer's disease may be delayed or prevented through risk modification. Because many neuropathologic processes begin decades before symptoms, interventions targeting diet and metabolism are likely most effective when initiated in midlife or earlier. While genetics load the gun, environment and lifestyle pull the trigger. Diet sits at the center of that environment.

A nutrient-dense, minimally processed dietary pattern acts on the very pathways that drive neurodegeneration: oxidative stress, mitochondrial dysfunction, inflammation, vascular injury, and metabolic impairment. The same foods that build and protect the brain also improve systemic resilience, lowering the risk of obesity, hypertension, dyslipidemia, diabetes, and frailty.

The implications for clinical practice are profound. Nutrition counseling should be viewed not as "adjunctive lifestyle advice," but as first-line neuroprotective medicine. If we can improve diet quality across the lifespan, shifting from ultra-processed to whole foods, from nutrient scarcity to abundance of color and quality protein, we may one day look back on late-life dementia as a largely preventable disease.

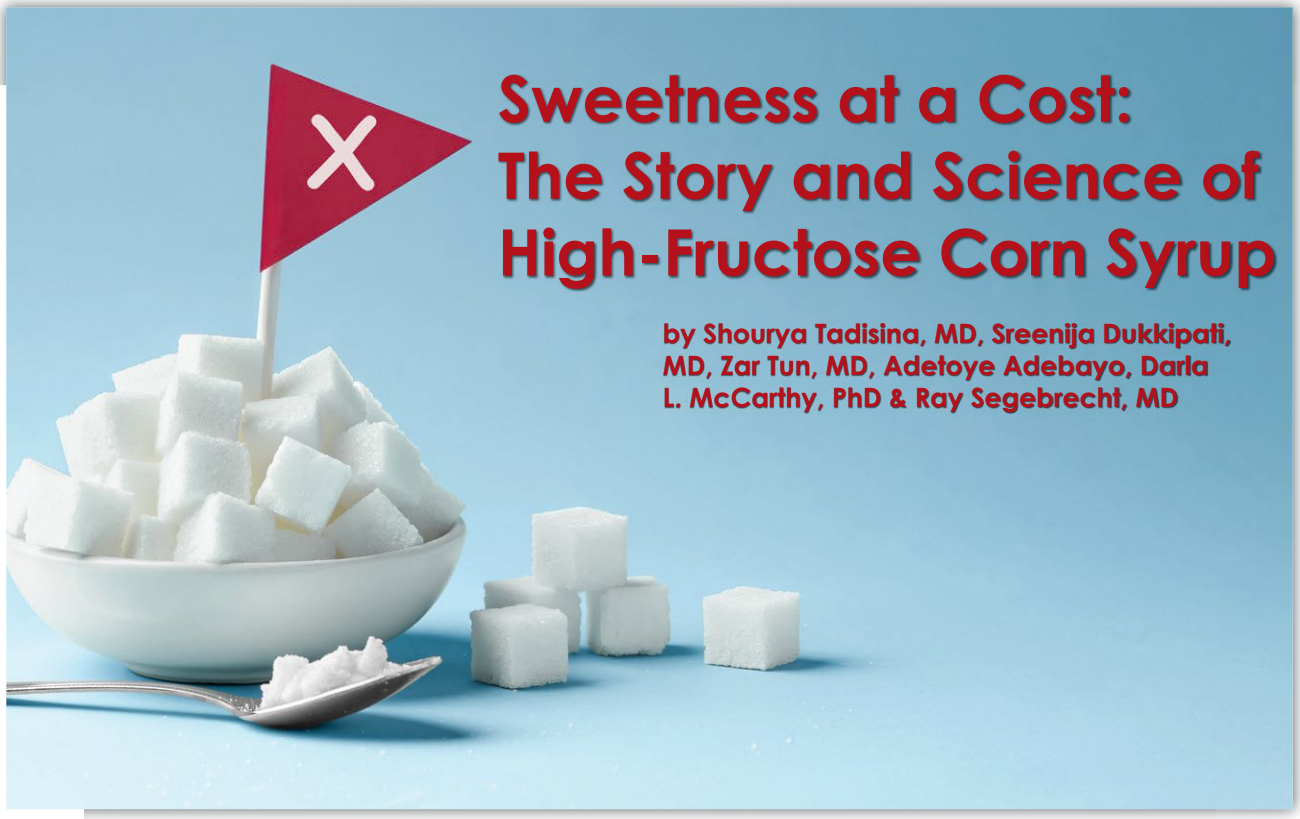
In short, the path to cognitive longevity is not found in the pharmacy; it begins on the plate.

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# Sweetness at a Cost: The Story and Science of High-Fructose Corn Syrup

by Shourya Tadisina, MD, Sreenija Dukkipati, MD, Zar Tun, MD, Adetoye Adebayo, Darla L. McCarthy, PhD & Ray Segebrecht, MD


## Overview

High-fructose corn syrup (HFCS) is a prevalent caloric sweetener in modern food, especially in sugar-sweetened beverages and ultra-processed foods. Fructose-containing sugars, such as sucrose and HFCS, exhibit unique hepatic metabolism that bypasses key regulatory steps, resulting in *de novo* lipogenesis, uric acid production, and insulin resistance. This review summarizes contemporary evidence linking excess fructose intake to cardiometabolic and cancer-related outcomes. We also trace the historical evolution of sugar research, including how mid-20th century emphasis on saturated fat resulted in delayed recognition of sugar's cardiometabolic risks, and we trace the rise of HFCS, driven by industrial, agricultural, and policy forces. We conclude our review by highlighting contemporary public health responses, including policy initiatives, dietary guidelines, and industry reformulations reflecting growing consensus that reducing fructose-containing sugar in the diet is central to decreasing cardiometabolic risks. While HFCS and sucrose are metabolically comparable, their widespread use in sugar-sweetened beverages and processed food forms facilitate excess intake, underscoring the need for continued public health interventions and clinical guidance aimed at limiting added sugars rather than substituting sugars.




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## Introduction

High-fructose corn syrup (HFCS) is a widely used caloric sweetener in the US food supply, particularly in sugar-sweetened beverages (SSB). HFCS is made from corn starch, and contains 42% (HFCS-42) or 55% (HFCS-55) fructose, with the remainder being glucose and minor oligosaccharides.[1] HFCS 55 is widely used in the US, especially in soft drinks, while HFCS-42 is more common in Europe due to regulatory restrictions. Fructose metabolism differs fundamentally from glucose metabolism, as fructose is primarily processed by the liver. The pancreas does not effectively sense fructose due to minimal expression of the GLUT-5 transporter, resulting in largely insulin-independent metabolism and lack of activation of central satiety pathways.[2,3]

With the widespread use of HFCS in SSB and processed foods, understanding any possible contribution to metabolic disease beyond calorie excess and mode of consumption remains a critical clinical and public-health priority. This paper examines the history of sugar research, health dangers of HFCS and sucrose, and modern evidence implicating fructose intake in adverse metabolic outcomes.

## History of Sugar Research and Industry

In the mid-20th century, coronary heart disease (CHD) mortality rose sharply in the US and Western Europe, and by the 1950s, CHD was the leading cause of death in the US. In response, the role of diet in the development of CHD became a significant focus of research. Early on, American physiologist Ancel Keys exerted substantial influence on the developing field of nutrition science. His Seven Countries Study examined associations among diet, lifestyle, and cardiovascular disease across diverse populations and helped establish the diet-heart hypothesis, which argues that dietary saturated fat raises serum cholesterol, thereby increasing the risk of CHD.[4] This hypothesis shaped research funding priorities, guided public policy, and informed nutrition guidelines for decades, positioning saturated fat as the primary dietary villain in public health discourse.

This strong emphasis on saturated fat limited support for alternative lines of inquiry, particularly studies examining dietary sugar as a potential contributor to chronic disease. At the time, physiologists and biochemists believed fructose to be relatively benign because it is metabolized primarily in the liver, does not require insulin for cellular uptake, and generates a smaller rise in blood glucose compared with other carbohydrates. Indeed, in the early 1950s through the 1970s, sugar was even marketed as a healthful substance that could help curb hunger (Figure 1).




Figure 1. An example of an old advertisement promoting sugar as a source of instant energy and a substance that can suppress appetite.

British physiologist John Yudkin emerged as a prominent critic of this view, proposing links between sugar consumption, insulin regulation, metabolic disturbances, and CHD.[5] A public and often contentious scientific rivalry between Yudkin and Keys contributed to the marginalization of sugar-focused research. Compounding this effect, the Sugar Research Foundation funded literature reviews in the 1960s that downplayed connections between sugar and CHD while reinforcing the narrative that dietary fat was the primary culprit.[6]

Rising rates of obesity and type 2 diabetes in the late 1970s, along with emerging biochemical evidence, began to expand the research landscape. Although

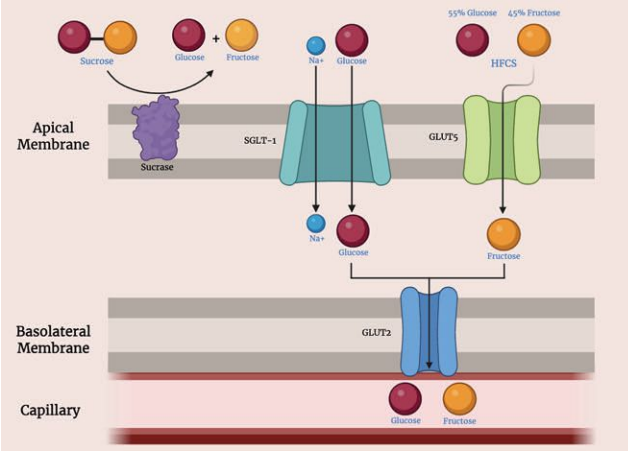



Figure 2. Comparison of sucrose and high-fructose corn syrup (HFCS) digestion and absorption within the small intestine. HFCS is typically composed of 55% fructose and 45% glucose, whereas sucrose is composed of single glucose and fructose molecules linked together by a glycosidic bond. On the apical membrane of enterocytes, sucrose is hydrolyzed by sucrase, releasing free glucose and fructose. Free glucose from both HFCS and hydrolyzed sucrase is transported into enterocytes through the Sodium-Glucose Cotransporter (SGLT-1), which uses sodium (Na+) to move glucose against its concentration gradient into the cell. Free fructose from both hydrolyzed sucrose and HFCS enters the enterocyte via GLUT5. Both monosaccharides exit the enterocyte across the basolateral membrane and enter circulation through GLUT2.

clinicians had long observed that conditions such as hypertension, hyperglycemia, and dyslipidemia frequently co-occurred, these abnormalities were not conceptualized as a unified clinical entity until Gerald Reaven's 1988 Banting Lecture, in which he introduced the concept of "Syndrome X" and proposed insulin resistance as its underlying mechanism.[7] Formal diagnostic criteria were established a decade later, and the definition of Metabolic Syndrome was further simplified and widely adopted following the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) report in 2001, which provided practical, measurable criteria for clinical and research use.[8] During this time, non-alcoholic fatty liver disease was recognized as a major disease, and fructose metabolism became better understood. Researchers revisited sugar as a risk factor for diabetes and cardiometabolic disease, and the door was opened to today's deeper understanding of sugar's metabolic effects.

## The Origin Story of HFCS

HFCS is produced from corn syrup, which is obtained by hydrolyzing corn starch into a liquid solution composed primarily of the monosaccharide glucose. HFCS is then created by treating corn syrup with an enzyme that converts a portion of its glucose to fructose. Because fructose is sweeter than glucose, this conversion yields a sweeter product than standard corn syrup.

The use of HFCS in US food and beverage manufacturing began in the 1970s, when it emerged as a convenient liquid alternative to sucrose.[9] As a liquid sweetener, HFCS eliminates the need to dissolve crystalline sucrose, reducing processing time and energy requirements. Its liquid form also simplifies transport and storage by enabling shipment in tanker trucks rather than dry bulk containers. HFCS is more stable than sucrose in acidic environments, making it particularly suitable for carbonated soft drinks, fruit-flavored beverages, and canned foods. Additional advantages such as improved moisture retention, enhanced texture, and improved browning characteristics in baked goods further contributed to its widespread adoption.

The use of HFCS expanded rapidly during the 1980s. Arguments have been made that this increase in HFCS use was driven in part by favorable pricing created by US agricultural policy. The argument holds that beginning in the 1970s, federal subsidy programs stimulated substantial growth in corn production, resulting in chronic overproduction and persistently low corn prices, making large-scale HFCS manufacturing economically attractive. At the same time, tariffs and quota restrictions on imported sugar elevated the cost of sucrose relative to corn-derived sweeteners, accelerating the industry's shift toward HFCS. These policy conditions were supported and promoted by HFCS producers and the corn lobby.

This argument is disputed; some economists contend that farm subsidies, tariffs, and quota restrictions had little bearing on HFCS adoption, and that market forces alone adequately explain the shift.[10] In any case, by the mid-1990s, per capita daily caloric intake of added sweeteners from HFCS nearly equaled that from sucrose.[9]

## Health Dangers of Fructose

Recent efforts in the US, at both government and corporate levels, have focused on removing HFCS from the national food supply. Food industry giant Tyson Foods recently announced that it would stop using HFCS in the products it distributes in the US.[11] In addition, the city of San Francisco has filed a lawsuit against 11 major manufacturers of ultra-processed food products, many containing HFCS, asserting that their practices have helped drive a growing public health crisis.[12] These events reflect growing public health scrutiny of HFCS and ultra-processed foods more generally, a key pillar of the Make

America Healthy Again initiative backed by US health leadership.

Sucrose and HFCS have similar glycemic indices and largely overlapping intestinal absorption pathways.[13,14] Sucrose, a glucose–fructose disaccharide, requires hydrolysis by the brush-border sucrase–isomaltase complex prior to absorption, whereas HFCS delivers free monosaccharides (≈42–55% fructose, remainder glucose), bypassing this step.[15] Following luminal availability, glucose is absorbed via the sodium-dependent cotransporter SGLT1, and fructose via the facilitative transporter GLUT5, with both exiting enterocytes through GLUT2 into the portal circulation[16] (Figure 2). These shared transport mechanisms yield comparable postprandial glycemic responses, consistent with similar glycemic index values for sucrose (~65) and HFCS (≈58–65). Both sucrose and HFCS share many similarities, including their caloric content and gastrointestinal absorption, and no significant consistent differences have been demonstrated between them on either metabolism or health.[15,17,18] Both types of sugar in excess can lead to multiple health problems, including type 2 diabetes and cardiovascular disease.[18] Recent reviews comparing sucrose and HFCS demonstrate largely comparable effects on insulin sensitivity.[19] Some studies, however, suggest potential differential tissue-specific effects, with HFCS more closely associated with hepatic insulin sensitivity and sucrose with skeletal insulin sensitivity.[20] Overall, systematic reviews show no significant difference in metabolic parameters between the two sugars, although HFCS intake has been found to increase C-reactive protein and apolipoprotein-B.[21,22] Table 1 summarizes recent studies comparing HFCS and sucrose.

In contemporary diets, fructose intake arises mainly from sucrose in baked goods and from HFCS in SSB and processed foods. While modest intakes are efficiently absorbed, higher doses overwhelm intestinal handling and increase hepatic fructose flux. Hepatic fructose metabolism is rapid and weakly regulated; fructose metabolism bypasses key glycolytic control steps, favoring *de novo* lipogenesis, triglyceride synthesis, and uric acid production, thereby linking excessive fructose intake to metabolic disease.[23]

Chronic fructose intake is associated with adverse cardiometabolic effects driven largely by hepatic fructose metabolism. Fructose potently stimulates hepatic *de novo* lipogenesis, leading to hepatic steatosis and, with sustained exposure, progression to inflammation and fibrosis. Accumulation of liver fat and inflammation contributes to systemic insulin resistance and obesity.[17,18,12] In parallel, fructose increases circulating triglycerides and very-low-density lipoprotein (VLDL) particles, thereby augmenting cardiovascular risk.[24] Rapid hepatic fructose metabolism is ATP intensive and promotes uric acid generation, which has been implicated in hypertension and kidney injury.[23,24] Emerging evidence also suggests that HFCS intake may disrupt gut microbial composition and increase intestinal permeability, facilitating translocation of proinflammatory mediators to the liver and further amplifying metabolic dysfunction.[23]

## Modern Research on Sugar and Its Dangers and Efforts to Educate the Public

The era of the perception that sugar is innocuous has officially ended. Recent systematic reviews, meta-analyses, and umbrella reviews of the meta-analyses on sugar in food and beverages has repeatedly demonstrated harm in multiple endocrine, cardiovascular, cancer, and other outcomes.[25,26,27] Specifically with respect to cardiovascular disease and type 2 diabetes, hepatic fructose uptake contributes directly to metabolic dysfunction following consumption of either fructose or sucrose by promoting hepatic lipid accumulation, insulin resistance, and dyslipidemia. In addition, excess sugar intake contributes indirectly by increasing adiposity and weight gain, which further exacerbates cardiometabolic risk.[18] An umbrella review showed that each daily serving of SSBs is linked to an ~9% increase in all-cause mortality, and 10% risk of cardiovascular events.[28] These recent studies have led to the Coca-Cola Company announcing the introduction of a US cane sugar sweetened formulation supplementing the longstanding HFCS version in 2025. Although cane sugar and HFCS are calorically and metabolically comparable, this shift reflects evolving consumer preference and renewed public and policy attention on sugar sources in processed foods.

With respect to cancer risk, sugar has been associated with multiple types, including breast, biliary tract, and colorectal cancer.[25,29,30] Additionally, sugar intake has been shown to be associated with increased cancer mortality in both breast cancer and colorectal cancer.[31,32] The cardiovascular disease increase with higher sugar consumption has been shown to be more of a problem than saturated fat consumption, prompting guidance to

Table 1. Recent literature review of different studies comparing the metabolic effects of high-fructose corn syrup with sucrose.

| Reference | Design/Duration | Population | Exposure/Comparator | Key Outcomes | Tier |
|---|---|---|---|---|---|
| Sigala et al., 2021 (JCEM)[19] | Researchers controlled participants' diets over a 2-week period (3.5 days of inpatient, followed by 12 days of outpatient); parallel-arm design (participants assigned to separate groups rather than a crossover); double-blinded (neither participants nor investigators knew which sugar was consumed); group assignment was not randomized. | 75 adults (ages 18-40); (BMI 18-35) | 25% of energy/total calories given from HFCS-SB(sweetened beverage) (n=28) vs 25% energy as sucrose-SB (n=24) vs an aspartame control (n=23) | Both HFCS and the Sucrose-SB decreased insulin sensitivity compared to the control. No significant difference between the HFCS and sucrose-SB was noted. | Tier I |
| Li et al., 2022 (Frontiers in Nutrition)[21] | Systematic review and meta-analysis of isoenergetic substitution trials) | The systematic review included 4 different published studies containing 9 distinct experimental groups, with a total of 767 participants | Direct comparison of diets consisting of HFCS (mean 19% energy) and sucrose (mean 19% energy) | Both HFCS and Sucrose diets saw no significant difference in weight, BP, or lipids. However, the CRP was slightly higher with the HFCS diet. | Tier I |
| Hieronimus et al., 2024 (Nutrients)[20] | 2 week dietary intervention | The study consisted of 187 young adults assigned to 8 dietary interventions consistent of various SBs (HFCS, sucrose, fructose, glucose, aspartame) | Sugar-SB types differ by fructose/glucose proportions (HFCS 55/45; sucrose 50/50) | Fructose intake was more heavily associated with liver insulin sensitivity, whereas glucose intake was more heavily associated with muscle insulin sensitivity. | Tier II (Not a clean HFCS vs sucrose comparison; focuses heavily on relationship with insulin and hepatic and muscular systems) |
| Fattore et al., 2021 (Nutrition Reviews)[22] | Systematic review and meta-analysis of isoenergetic sugars/substitution trials | 25 studies involving 1744 volunteers were identified. | HFCS or fructose was replaced with glucose or sucrose; similar energy conditions were maintained | No significant effects were found when HFCS or fructose was substituted with sucrose, with the exception of a small increase in apolipoprotein B when HFCS was replaced with sucrose. | Tier I |
| Liu et al., 2023 (PLOS ONE)[38] | Systematic review and meta-analysis of controlled studies including controlled feeding trials of over 7 days | 93 reports of controlled feeding trials with147 trial comparisons (N = 5213) | Sugars that contain fructose were analyzed based on the foods they come from and whether the diets controlled added calories or maintained calories | When fructose containing sugars replaced other sources of carbs, there was no significant increase in blood pressure. | Tier II |
| Zane/Yu et al., 2025 (Frontiers in Nutrition)[39] | Systematic review focused specifically on HFCS and markers of liver disease and injury (MASLD/NAFLD) | 20 texts reviewed in full with 1 significant selection consisting of adults-HFCS human evidence based. | The study analyzed the amount of HFCS consumed and how consumption affected liver/glucose markers | Because there was only 1 eligible human study, there is a major deficit in research for HFCS and liver outcomes | Tier II |
| Guntari et al., 2025 (*Food & Nutrition Research*)[40] | Systematic review and meta-analysis of randomized controlled trials looking for metabolic biomarkers. Intervention durations from 7hours to 49 days. | 7 clinical trials were conducted with a total of 17 study comparisons. Participants were adult humans (male and female) with a diverse BMI range among participants. | Diets of fructose-containing sugars (HFCS and sucrose) vs diets of non-fructose containing sugars (glucose, other carbohydrates) were compared. Controlled energy across groups. | Evidence mixed/results were inconsistent. In some subgroups, fructose-containing sugars were associated with an increase in biomarkers such as uric acid and various lipids. | Tier II |

shift from replacing saturated fat with carbohydrates, especially refined carbohydrates, to reducing fructose-containing sugars like sucrose and high-fructose corn syrup.[33,34] While not abandoning trans-fat minimization in their guidelines, the 2019 ACC/AHA Guideline on Primary Prevention of Cardiovascular Disease now also emphasizes refined carbohydrate and sweetened beverage reduction.[35] The AHA recommends that adult women consume a limit of about 25 grams of added sugars per day and adult men consume a limit of about 36 grams per day as a part of heart-healthy diet.[36] Similarly, the American Cancer Society guidelines for diet also highlight the reduction of sugar sweetened beverages and highly processed foods and refined grain products.[37]

## Conclusion

HFCS and sucrose are metabolically similar, with comparable absorption and glycemic effects. However, excess fructose intake, whether in the form of sucrose or HFCS, has important downstream consequences independent of glycemia. High-dose exposure, particularly from SSB, increases hepatic fructose flux and promotes lipogenesis, dyslipidemia, insulin resistance, and uric acid generation, leading to obesity and type 2 diabetes mellitus and increasing cardiovascular and cancer risk. Contemporary mechanistic and epidemiologic evidence now clearly links fructose-containing sugars to cardiometabolic disease. Accordingly, reducing excess added sugar – rather than substituting one sweetener for another – should remain a central public health priority.

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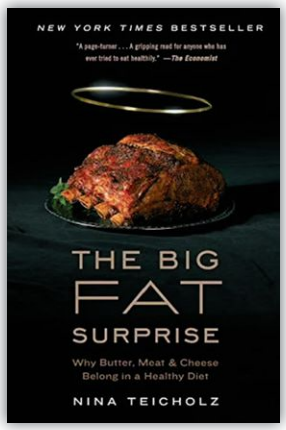

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BOOK REVIEW

# The Big Fat Surprise

*by Nina Teicholz*
*Submitted by John C. Hagan, III, MD*

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Available on Amazon, Audible, Kindle




The Big Fat Surprise is a gripping, meticulously researched indictment of the modern nutritional consensus, arguing that the demonization of saturated fat was based on flawed science rather than rigorous evidence. Teicholz exposes the political and industry pressures that shaped dietary guidelines for decades, making a compelling case for a paradigm shift back toward whole, high-fat foods. It is a transformative, must-read critique for anyone questioning the foundations of modern nutritional health advice.

With eye-opening scientific rigor, The Big Fat Surprise upends the conventional wisdom about all fats with the groundbreaking claim that more, not less, dietary fat—including saturated fat—is what leads to better health and wellness. Science shows that we have been needlessly avoiding meat, cheese, whole milk, and eggs for decades and that we can now, guilt-free, welcome these delicious foods back into our lives.

- A *New York Time*s bestseller
- Named on of *The Economist*'s Books of the Year 2014
- Named on of *The Wall Street Journal*'s Top Ten Best Nonfiction Books of 2014
- *Kirkus Reviews* Best Nonfiction Books of 2014
- Forbes's Most Memorable Healthcare Book of 2014

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# Toxicology Testing: Interpreting What That Number Means

*by Nancy Mikati, MD, Eniola Gros, MD, Hannah Spungen, MD, Michael D. Levine, MD & Evan S. Schwarz, MD*

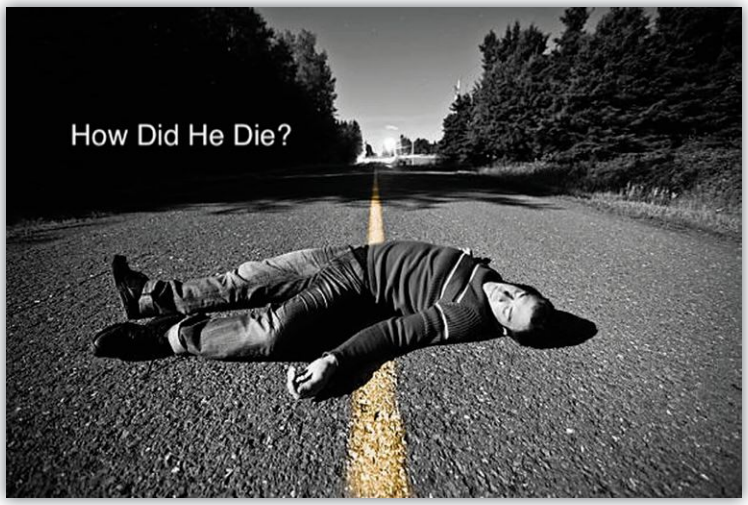
## Introduction

When someone dies, toxicology testing may be obtained to determine the cause of death. Toxicologic testing is an important part of both clinical care and forensics. Unlike what may be portrayed on television, this process is a lot more complex. Using reliable and specific analytical methods is imperative. Inappropriate selection of testing modality or misinterpretation of laboratory findings may result in faulty conclusions, which depending on the context (e.g., legal), could have devastating consequences. Information obtained from testing must be interpreted in the context of the circumstances of death; for example, a person who died while sleeping is unlikely to have died from stimulant toxicity, even if amphetamines are identified in their blood. Additionally, it is important to understand how the testing was conducted and what biologic matrix (e.g., blood, serum, urine) was used to properly interpret the results. Testing modalities and biologic matrices each have their benefits and limitations. Collection, preparation, and storage of samples, in addition to the choice of biologic matrix, also plays an important role in correctly interpreting the results.



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Finally, postmortem redistribution, the idea that toxicology concentrations ("levels") may change after death, is important to consider when interpreting toxicology testing.




## Types of Toxicology Testing

Immunoassays are often used as an initial screening test, with positive results generally followed by a more specific form of confirmatory testing, especially when used for forensics. There are situations, particularly in clinical medicine, where confirmation is not necessary (e.g., patient confirms that the immunoassay is accurate). Immunoassays use an antibody directed at a specific part of the compound to identify it. The antibodies can cross-react with similar structures allowing them to identify multiple members of a drug class or mistakenly interact with compounds of a different drug class resulting in a false positive test.[1] They provide rapid and cost-effective results for common substances but have significant limitations.[1,2]

In hospitals, the urine drug screens that are ordered and result quickly are almost always immunoassays. Reference and send-out laboratories, which are used for forensic testing, often utilize immunoassays as their screening test. However, the immunoassays used by the hospital and reference laboratory are basically the same technology used in direct-to-consumer drug tests that are available for purchase in drug stores or pharmacies. The result of an immunoassay is typically reported as positive or negative. Reporting a "positive" or "negative" result for a family of substances (e.g., opioids) can be misleading, however. Immunoassays generally only identify a subset of substances in a drug class, yielding false negative results (e.g., only identifying a few amphetamines but not all amphetamines), as well as false positives due to cross-reactivity with similar substances.[1,2] Immunoassays for opiates generally test for morphine, which is a metabolite of heroin and codeine. Therefore, opiate testing by immunoassay will only identify substances with very similar chemical structures to or that are metabolized to morphine. This is why separate immunoassays are required to identify other opioids such as oxycodone, methadone, fentanyl, and buprenorphine.[2,3]

Gas chromatography-mass spectrometry (GC/MS) and liquid chromatography mass-spectrometry (LC/MS) combine the separation power of chromatography with the high specificity and definitive identification power of mass spectrometry and are generally used to confirm positive findings from the immunoassay.[1,2] Chromatography uses properties of the substance (e.g., how lipophilic it is) to separate out the various compounds that require identification. There are multiple forms of chromatography, including liquid or gas, which indicates the phase of the substance or compound when it is being separated. In LC, unknown compounds move up a column which causes them to be separated before being placed in a spectrometer. Following the separation, spectrometry is a method that uses an ionization source to generate molecular fragments that create a characteristic molecular signature that can be used to analyze and identify substances.[3] The most common forms of spectrometry includes mass (for molecular weight), nuclear magnetic resonance (for identifying structure), optical (for determining chemical bonds and electronic states), in addition to emission and absorption-based methods. In some situations, chromatography is used without spectrometry to identify the substance of concern based on how far up the column the compound traveled, referred to as the retention time. The correct choice of biologic sample, in addition to preparation of the sample, is imperative when using MS due to its limitations with analyzing drugs or compounds that are highly polar, large, or heat-sensitive/thermally unstable.[1–3] Some advantages of GC/MS or LC/MS modalities include their multiplexing capabilities: analyzing hundreds of substances simultaneously and

providing structural information i.e., molecular weight and structural confirmation of unknown compounds.[1]

With the increasing frequency of novel synthetic substances in the illicit drug supply worldwide, there is a demand for unknown substance screening and identification. This is particularly true in forensics when attempting to identify substances that contributed to the cause of death.




Identifying substances on GC/MS or LC/MS can involve either directed (targeted) or undirected testing. Directed screening is obtained by matching the resulting spectra (the compound of interest) to a spectrum library, which corresponds to compounds representing various pharmaceuticals, illicit drugs, and their metabolites.[1–3] Drugs such as amphetamines, cocaine, opioids, benzodiazepines, neuroleptics, and their respective metabolites are quantified using LC-MS in what is called multiple-reaction-monitoring (MRM) mode. This is essentially a highly sensitive 'fingerprint' to target and quantify specific molecules of the desired drug. Some substances like ethanol and various toxic alcohols (e.g., methanol) are volatile, requiring heating and subsequent vaporization. The vapor sample is then injected into a GC which separates the ethanol from other volatile compounds. All results are compared to the internal standard to determine the exact concentration of the sample. In undirected testing, the laboratory uses what is plotted by the spectrometer to identify an unknown substance.

Given the frequency of novel psychoactive substances adulterating the drug supply, it is important to know if the laboratory is using directed or undirected testing. For instance, in the case of death from a suspected opioid overdose, if the opioid is one that has not previously been detected in the drug supply, the MS may not identify it if it is only matching the substance to what is in the laboratory's known library (directed testing).

While chromatography and spectrometry are considered the gold standard in identifying most substances, these modalities still have limitations. The testing requires greater technical expertise and has longer turnaround times compared to immunoassays.[3] Many hospitals and even state forensic laboratories send specimens to reference labs to obtain GC/MS or LC/MS testing. More importantly as will be discussed, a positive postmortem screen does not indicate cause of death, and therefore, it is imperative that the clinician evaluating these results incorporates medical history, previous exposures and tolerance, and circumstantial information before making conclusions.[4–6]

## When "Positive" and "Negative" Aren't Absolute

While a test may be reported as positive or negative, it actually depends on exceeding a threshold to be considered "positive." Immunoassays and chromatography/spectrometry are all generally based on a cutoff when resulting as either positive or negative. The established cutoff must be high enough to minimize false positives but also low enough to prevent false negatives, particularly in patients with a history of chronic use of the xenobiotic in question.[7] Essentially, the cutoff that is used is a tradeoff balancing sensitivity and over-detection. Higher thresholds can result in false negative testing; there is not enough of the substance in the sample to turn the test positive, although the substance is technically in the sample. This can be problematic in forensic testing as someone may have substances in their blood or urine, but the test is reported as negative. Cutoffs at lower concentrations can lead to a more sensitive immunoassay or LC-MS/MS confirmatory analysis but may also complicate interpretation. The test will be positive at lower concentrations of the drug but

may cause a positive test for a concentration that is clinically insignificant.[8] While manipulating the threshold may seem problematic, it may also be done in a way that is beneficial.[7,8] For instance, by raising the cutoff threshold, immunoassays are incredibly unlikely to be positive for opioids or cannabinoids from eating a poppyseed bagel or being exposed to second-hand cannabis smoke, respectively. Again, the laboratory director or test manufacturer can manipulate the threshold resulting in a positive test depending on their goals of detection. While there are predetermined concentration cutoffs, the presence of a detectable amount of the xenobiotic does not necessarily imply functional impairment—particularly in patients with tolerance.

Additionally, interpretation of drug concentrations must also be done in the context of the pharmacodynamics and kinetics (e.g., mechanism of action, metabolism, potency, efficacy or therapeutic index) of the substance. Also, sampling may not be witnessed and is easily susceptible to tampering, although this is less likely an issue in forensic testing which entails specific chain-of-custody procedures. Finally, the matrix tested must also be considered as blood or serum sampling has a narrower detection window compared to urine.

## What is Postmortem Redistribution?

In forensic toxicology when someone dies under suspicion of a drug or medication overdose, it is not appropriate to draw a concentration (a "level") and compare it to an antemortem sample. Immediate postmortem or perimortem samples may be interpreted similarly to antemortem samples (i.e., the sample is drawn very close following death). However, when there is a delay in obtaining the samples, interpretation of the concentration must take into consideration the concept of postmortem redistribution. Since drug concentrations and distribution continue to change after circulation stops (i.e., death), the interpretation of postmortem toxicology findings is heavily affected by the time elapsed since death.[9] Sometimes, the exact time of death is uncertain and "last known alive" estimates may be imprecise. Bodies are sometimes discovered hours or days later, leading to marked variability in the extent of decompensation and postmortem changes at the time samples are collected.[10,11] In forensic toxicology, postmortem redistribution describes the measurement of drug and toxin concentrations after death, which may be different from the antemortem value.

Postmortem redistribution makes interpretation of drug concentrations challenging because substances diffuse from organs with high tissue concentrations (e.g. liver, lungs, myocardium) into the bloodstream once circulation ceases.[12,13] This can lead to falsely elevated concentrations in central blood samples (e.g., from the heart or major thoracic vessels) that do not reflect antemortem (prior-to-death) concentrations.[12,14] Peripheral blood, especially femoral vein samples, is therefore preferred, as it is less affected by redistribution, and therefore, more closely reflects antemortem circulating concentrations.[13,14] Results are best interpreted by comparing concentrations across multiple specimens, including peripheral and central blood, solid tissues, urine, and vitreous humor, to assess consistency and identify redistribution patterns (i.e., how likely it is that a particular substance undergoes postmortem redistribution).[14,15] While hair and nail testing may help document long-term or prior exposure, they are not reliable indicators of acute intoxication at the time of death.[16]

Gastric postmortem redistribution occurs when drugs that remain in the gastrointestinal tract at the time of death diffuse across the stomach or intestinal wall into nearby tissues and blood. This can produce artificially elevated drug concentrations in central blood samples after death.[9,12,14] Unabsorbed drug in the stomach or intestines effectively acts as a postmortem reservoir, contributing to delayed redistribution and further complicating the interpretation of postmortem drug concentrations.[9] In addition, gut bacteria may continue to metabolize or degrade certain drugs after death, leading to differences between antemortem and postmortem concentrations and altering parent drug–metabolite ratios.[9,11,17] For example, ethanol concentrations may change after death as a result of microbial fermentation, meaning measured concentrations do not always reflect antemortem exposure.[18] Cocaine and heroin are also vulnerable to postmortem chemical breakdown; cocaine can hydrolyze to benzoylecgonine, while heroin rapidly degrades to 6-monoacetylmorphine and morphine, which can significantly alter parent drug–metabolite ratios.[13,19] In addition, some benzodiazepines and opioids may show postmortem degradation or redistribution, particularly when there is prolonged gastrointestinal stasis or bacterial overgrowth.[9]

Other factors can both increase and decrease postmortem concentrations. Ongoing diffusion of drugs between tissues and blood, along with postmortem metabolism of certain drugs, may also result in lower parent drug concentrations and different metabolite patterns than would have been present antemortem.[9,11] Additionally, environmental factors, particularly temperature and humidity, further affect the rate of decomposition and can accelerate redistribution and drug breakdown.[9,17] As a result, certain drug concentrations measured at the time of discovery of the body may differ substantially from drug concentrations at the actual time of death. Therefore, since both time and environmental conditions influence postmortem changes, they should be considered when interpreting the role of drugs in death.[9,11]

Interpreting postmortem toxicology results also requires an understanding of drug-specific pharmacokinetics, since properties such as lipophilicity, protein binding, and volume of distribution influence the degree and pattern of postmortem redistribution.[9,13] Highly lipophilic drugs with large volumes of distribution tend to accumulate in adipose tissue and well-perfused organs during life. After death, these tissue stores can release drugs back into the bloodstream, often resulting in elevated concentrations in central blood samples.[9,12,14] In contrast, hydrophilic drugs with low volumes of distribution and minimal tissue binding undergo less redistribution, so measured blood concentrations more closely reflect antemortem concentrations.[11,13] Protein binding also plays a role, as only unbound drug is able to diffuse across tissue and vascular compartments after death.[9] Body habitus further modifies these effects; for instance, in individuals with significant adipose tissue, fat can act as a larger drug reservoir, prolonging postmortem release and altering concentration gradients.[9,12,14] These pharmacokinetic factors should therefore be considered when evaluating postmortem drug concentrations and determining toxicologic contribution to death.

## When Chemistry Misleads: Analytical Artifacts After Death

Analytical pitfalls can further complicate interpretation in postmortem toxicology, as certain compounds may be produced or altered after death, creating results that do not reflect true antemortem conditions.[10,11] Microbial activity during decomposition, for example, can generate ethanol through fermentation of glucose in blood or tissues, potentially leading to a false impression of alcohol ingestion.[18,20] This is why vitreal sampling for alcohol is preferred.[20] Ongoing cellular breakdown and bacterial metabolism may also shift concentrations of organic acids, ketones, and other endogenous substances, sometimes mimicking metabolic disturbances or toxic exposures.[17] Additionally, hemolysis, tissue autolysis, and extended postmortem intervals may interfere with assay performance or produce cross-reactivity in analytical methods.[10,11] Hence, careful specimen handling, use of preservatives, selection of appropriate matrices (such as vitreous humor for ethanol confirmation), and correlation with scene and clinical history are essential to distinguish true toxicologic findings from postmortem artifacts.[15,20]

## It's More Than Just a Number

Estimating antemortem drug concentrations from postmortem specimens is challenging and should be done with caution, if at all. Postmortem measurements cannot be reliably back-calculated to precise antemortem concentrations; however, they may be used to assess whether antemortem concentrations were likely low, within a therapeutic range, or potentially toxic.[9–11] It is important to remember that even this simplification is nuanced. Once a tested sample yields a positive result or concentration ("level"), the interpreter must consider the dose-response relationship, which refers to the quantitative association between the amount of drug consumed and the intensity of its effect. Tolerance of the user and the time between exposure and collection can affect quantitative results and interpretation.

For instance, when interpreting postmortem opioid concentrations, tolerance must be considered. In someone without tolerance (no chronic use), opioid concentrations may be low or in a therapeutic range but still be toxic, while for someone with an opioid use disorder, a moderately high concentration might not be expected to be harmful. Several pharmacokinetic variables are usually unknown, including the timing of ingestion, the exact dose taken, and whether the formulation was immediate or extended-release. If known, these are all important considerations when interpreting the concentration.[13]

Medical interventions prior to death may introduce confounders which may add an additional layer of uncertainty when interpreting the test.[21] For example, intravenous fluids may dilute blood drug concentrations, vasopressors can change tissue perfusion and drug distribution, and cardiopulmonary resuscitation can cause unpredictable redistribution of drugs between compartments. Emergency treatments such as activated charcoal or antidotes may also alter absorption, metabolism, or elimination. This indicates that postmortem concentrations may reflect post-intervention rather than true pre-collapse concentrations.[11,21] Therefore, these factors make precise calculation of antemortem drug concentrations from postmortem samples unreliable.

## Conclusion

Toxicology testing is a common component of determining if drugs contributed to a fatality. Knowing the biologic matrix and understanding the form of testing, and its limitations, are imperative to properly contextualize the laboratory value. Immunoassays and chromatography have their benefits as well as limitations. Reports may be issued with both qualitative and quantitative values. It is particularly important to know the cutoff for qualitative testing when interpreting the result as either positive or negative. Substances may also undergo postmortem redistribution which can cause them to elevate after death. Additionally, some substances are metabolized following death resulting in lower concentrations compared to antemortem values. All these factors must be considered when interpreting biologic testing to properly determine if the measured substance contributed to the cause of death.

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# St. Louis Metropolitan Medical Society's Medical Historical Museum – National Museum of Quackery (1964-1984)

*by James R. Wright, Jr., MD, PhD & Kristina Hampton, MA*

The St. Louis Metropolitan Medical Society (SLMMS, n.b., its name was the St. Louis Medical Society before merging with the St. Louis County Medical Society in 1979) opened its Medical Historical Museum in May 1964. It was conceived by the Society's Executive Director, Hollister Smith, and a committee of six SLMMS members chaired by John Byrne. Part of the rationale for the museum was to celebrate the bicentennial year of the founding of the City of St. Louis.[1-3]

When the Museum opened, its main features were a reproduction of a doctor's office from the 1860s (Figure 1) and a pharmacy from the 1880s. There were also tributes to "the first and foremost among the city's early doctors, Antoine Francois Saugrain [1763-1820] and William Beaumont [1785-1853]."[1] Saugrain was a Parisian physician, chemist, and minerologist who established a medical practice in St. Louis in 1799. Beaumont, a former US military surgeon who had previously been based on Mackinac Island, Mich., where he had performed physiological studies on a patient with a gastro-cutaneous fistula, practiced medicine in St. Louis from 1833 to 1853. There were also displays describing St. Louisans who had won Nobel Prizes: Edward Doisy (1893-1986), Joseph Erlanger (1874-1965), Arthur H. Compton (1892-1962), and Carl and Gerty Cori (1896-1984; 1896-1957).

Also featured were display cases filled with old surgical instruments, including amputation kits from the Civil War. Shortly after its opening, the doctors generated a souvenir brochure.[4]

In March 1967, after the Food and Drug Administration provided ~180 confiscated quackery artifacts, the museum added a "Quackery Corner"



Figure 1. Partial view of 19th century doctor's office exhibit. Courtesy of the Saint Louis Science Center.



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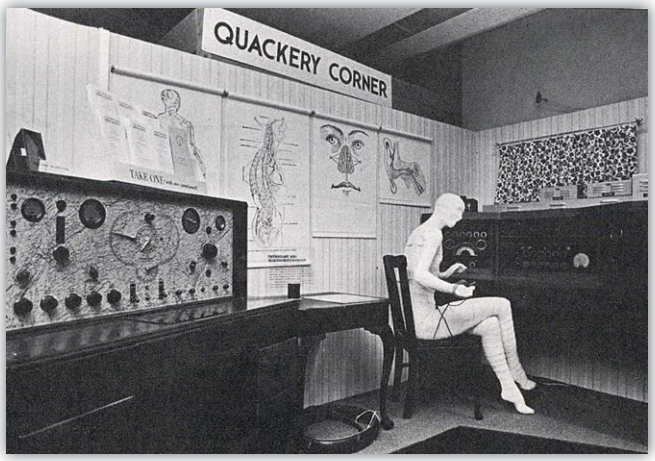





Figure 2. Above: Manikin seated in front of a reflexophone electro-metabograph device developed by Albert Abrams (1863–1924), the "dean of 20th century charlatans." The device could allegedly diagnose almost any disease and determine life expectancy. Dr. Abrams claimed that different diseased organs and tissues vibrate at different frequencies. By blasting the specific frequency back into the diseased tissue, the patient would be cured. Below: Some of Dr. Abrams other radionic devices.[19] The American Medical Association spent much time and effort debunking Abrams' devices and theories. *Courtesy of the Saint Louis Science Center.*

(Figure 2) and was renamed the Medical Historical Museum and the National Museum of Quackery.[5] In 1968, the SLMMS published a small booklet detailing the museum's exhibits. Its foreword reads:

"To record the dramatic story of the practice of medicine in St. Louis for two hundred years, the Board of Curators of the St. Louis Medical Society has developed a medical museum featuring a collection of items that gives a living picture of decades of physicians who have been responsible for the health of this community. This collection of their books, papers, instruments, apparatus and furniture is intended to preserve a priceless heritage."[5]

In the 1970s, the museum had a wide variety of displays that depicted topics such as medicinal herbs and Native American medicine. There were life-size dioramas illustrating the first hospital west of the Mississippi (established in 1828 by the Daughters of Charity, n.b., DePaul Hospital is currently the oldest continually operating business in St. Louis), the first medically-directed hospital laboratory in St. Louis (St. Mary's Infirmary), multiple 19th century physicians' offices, as well as two hospital pharmacies.

Displays on the founding of the St. Louis Medical Society, medical books written by St. Louis physicians, medical journals established and "edited by St. Louis men of medicine" beginning with the St. Louis Medical and Surgical Journal (1843), and Dr. Robert E. Schlueter's Paracelsus book collection highlighted significant holdings from the SLMMS Library. Additional displays showed the founding of the 47 other St. Louis hospitals starting with City Hospital in 1847, and the establishment of 22 St. Louis medical colleges (mostly proprietary schools with low standards that were by then long gone).[6,7]

There were displays highlighting endocrinological studies in the Department of Medicine at Washington University (WU) in the 1920s and 1930s, including the case of Robert Wadlow (1918-1940), the Alton giant, who at 8 feet 11 inches is still listed by the Guiness Book of World Records as the tallest person who ever lived. There was a display on early Black physicians in St. Louis as well as the formation of the Mound City Medical Forum in 1920, the first local component society of the National Medical Association established west of the Mississippi.

Other displays featured surgeon John T. Hodgen (1826-1882), who became an expert on caissons disease during the Eads Bridge construction (1869-1871); anesthesiologist Thomas F. Hornbein (1930-2023), who developed a high-altitude oxygen mask and used it as a member of the first team to climb the west ridge of Mt. Everest; ophthalmologist John Green (1835-1913), who was the first specialist west of the Mississippi; plastic surgeon Vilray Blair (1871-1955); and surgeon Evarts A. Graham (1883-1957), who pioneered one-stage pneumonectomy and cholecystography (Figure 3).[6,7]



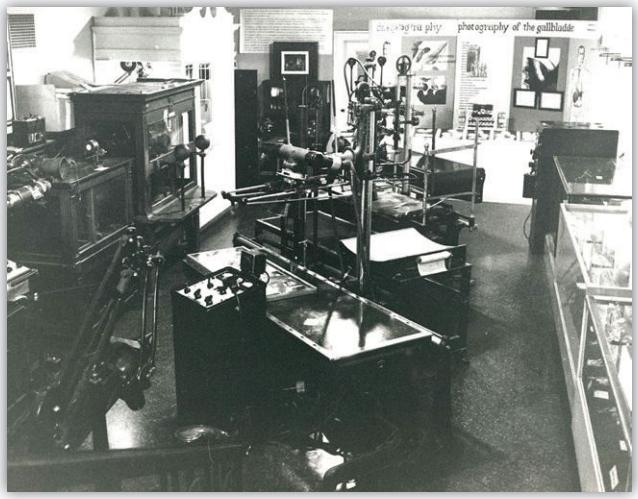



Figure 3. Above: A diorama commemorating Evarts Graham's pneumonectomy. Below: The Museum's history or radiology room with its cholecystography display on its back wall. Courtesy of the Saint Louis Science Center.

## Hard Times

In the late 1970s, in the context of deciding whether to renovate the current SLMMS building or build new quarters elsewhere, a long-range planning committee discussed closing the museum. By the early 1980s (i.e., once it had been decided to renovate the building), some SLMMS leaders envisioned redeveloping the museum's current space and renting it to a revenue-generating organization. The Museum of Science and Natural History, the predecessor of the Saint Louis Science Center (n.b., SLSC was actively being planned but would not open until 1985, see below), held internal discussions as well as some preliminary discussions with SLMMS Executive Director Gordon (Ron) Garrett about whether the Medical Museum artifacts should be donated to the new SLSC. From extant correspondence, SLSC Executive Director Dwight Crandell clearly recognized that the goals of each organization were not entirely aligned as the SLSC was ultimately interested in educating the public about the human body while the Medical Museum's interest was the history of medical and surgical tools, noting that many of these "seem to command little interest to any but medical students and old doctors."[8]

The Museum had been accredited by the American Association of Museums in November 1971 but ran into serious trouble in the early 1980s when its accreditation was up for renewal. The Museum was being run as a nonprofit organization by the St. Louis Society for Medical and Scientific Education (SLSMSE); SLSMSE's stated purpose was: "…the creation of a medical library, medical museum, and a medical forum providing lectures…"[3] Unfortunately, the museum had not kept up with changing times in the world of museology.

In February 1982, one month before an accreditation site visit, SLSMSE hired Mary G. (Polly) Park (1935-2020), an art historian and wife of prominent WU neurosurgeon William S. Coxe (1926-2012), as its Museum Director. Prior to that, Executive Director Smith, who helped build the museum in 1964, had loosely functioned in that role, but his primary interest had been adding to the collection rather than developing it; Smith was now retired.

The site visit identified many issues. Accreditors described the museum as "a huge potpourri collection that requires a few years of processing." They noted that the museum was overcrowded, and it desperately needed to catalog its current collection, establish a collecting policy statement to guide in future acquisitions, and identify safe, environmentally controlled storage space for duplicate materials not needed for display. They noted that "the cost of operating the museum are included in the operating budget of the parent society and are impossible to isolate and identify," precluding long-term planning.[3] Finally, the accreditation report stated that:

"There is urgent need for orientation so that visitors know instinctively that tours start at a particular point, or in an obvious area… The exhibits are episodic and do not flow naturally from one to another… a museum dealing with difficult medical concepts needs storylines that have beginnings, that show development or progress, and have endings."[3]

Reaccreditation was withheld, leaving Garrett and the SLSMSE with big problems to solve. While Park addressed the "episodic" issues identified in the report, staffing levels precluded addressing the cataloging issues. On February 22, 1984, discussions with the SLSC began in earnest. A week later, SLSC staff visited the museum and estimated that, above and beyond the cost of building renovations, it would cost several hundred thousand dollars to redevelop the current 3,000 square foot museum displays with plexiglass casings, optimal labeling, and proper lighting. Considering the size of the collection, they estimated that it would take almost five years for a qualified fulltime person to process the collection materials. Discussions pertaining to merging the Medical Museum into the SLSC ensued immediately.

On July 17, 1984, the SLMMS membership was sent a letter, a copy of a transfer proposal, and a questionnaire. Members were told that the Board of Trustees of the SLSMSE and the Council of the SLMMS had both voted unanimously to transfer the museum to the SLSC. The membership was asked to vote to either approve the transfer, or if not in favor, to support a dues increase of either $35 or $75 per year. Of the 2,665 surveys mailed, 604 were returned and analyzed: 85% supported the Board's decision; 10% and 4% of respondents were willing pay $35 and $75 per year to keep it.

Internal discussions continued within the SLSC as to how to utilize the Museum's holdings. A proposal to develop a series of up to ten chronologically organized "period rooms or life-size dioramas" was presented to Executive Director Crandell.[9] Crandell's response was: "I have some misgivings about the extent of dioramas… In the spirit of collaboration, we might consider approaching the Missouri Historical Society to put up either permanent or temporary displays on historical content dioramas. While I love historical displays, I feel we should minimize their use in our own building."[10]

On December 4, 1984, the SLSMSE and the SLSC executed an agreement transferring the museum artifacts to the SLSC. It was agreed that the collection would remain intact and would be designated as the "SLMMS Collection." A SLMMS Collection Curator position was created for three years and "an Advisory Committee comprised solely of six Medical Society members [was] created for the purpose of advising in all facets of the management of the SLMMS Collection." The agreement generally outlined how the collection would be used and credited.[11] Coxe was hired as SLSC Assistant Curator for Medical Technology on January 1, 1985.

The SLSC building did not officially exist yet and so all parties recognized the artifacts would need to be temporarily stored.

## Saint Louis Science Center's Openings

The first SLSC site, the James S. McDonnell Planetarium Building in Forest Park, opened on July 20, 1985. The Science Center organizers had acquired the Planetarium from the city several years earlier. SLSC leadership had also acquired the Falstaff Brewing Company office building at 5050 Oakland Avenue on a rent-to-buy basis. The two buildings were adjacent but on opposite sides of Highway 40. Planning was underway to build a skybridge across the highway connecting the buildings.

Issues soon arose related to when and where the SLSC would first display SLMMS museum artifacts. The agreement stated the collection would be utilized in the SLSC's first major exhibit in the Science Center building (i.e., 5050 Oakland); however, planning was in a state of flux. While initial plans had been to heavily renovate the ~70,000 square foot, five-level office building and extend the building with ~105,000 square feet of new construction on the north and south facades, it quickly became clear that it would be better to demolish it and create a purpose-built structure; however, this would delay the opening. In December 1985, the SLMMS requested, since exhibits at 5050 Oakland would not open until after 1986, that the SLSC allocate at least 500 square feet in its Planetarium building for the Society's 1986 sesquicentennial celebration and assign Coxe to install appropriate medical exhibits. Before this request, neither Coxe nor the SLSC were aware of plans to celebrate the 150th anniversary.

In March 1986, Arthur H. Gale (1930-2025), Chair of the SLSC Medical Advisory Committee (see below), proposed a compromise; a display case entitled "Instruments of Change" was exhibited at Plaza Frontenac Mall in St. Louis from July 21 to October 31, 1986, and then was next displayed for two months at the Planetarium. A traveling medical history exhibit entitled "Send Us a Lady Physician" was displayed at the Planetarium simultaneously. In February 1987, Coxe gave a talk on medical quackery as part of a lecture series celebrating the sesquicentennial. Overall, the sesquicentennial celebration was a success.

## Medical Museum Advisory Committee

When one of the authors (JRW) arrived in St. Louis as a pathology resident at Barnes Hospital in July 1984, the SLMMS museum was winding down. Later that year, the SLMMS sought to populate a Medical Museum Advisory Committee. JRW volunteered and was appointed on January 28, 1985. The advisory committee was chaired by Arthur H. Gale. The committee's designated purpose was to "advise St. Louis Science Center on plans of the Museum for development, recommend changes and additions to the Museum, and ways and means of securing financial support." The committee's focus, name, meeting locations, and membership morphed over the next few years.

The Medical Museum Committee had initially believed that large portions of the collection could be displayed together as a 3,000 square foot unit in the Falstaff office building. The committee supported exhibits "incorporating medical artifacts according to a chronological unfolding of the history of medicine" and providing "a chronological approach of turning points in 20th century medical progress."[12,13] Expectations soon grew into a proposal estimated to occupy 7,000 square feet.[14] Enthusiasm within the committee waned with the news that there had been a change of plans related to the Falstaff building (see below) and that this had created new space constraints.

On October 13, 1987, Gale wrote Crandell: "We would like to discuss in general terms the future of the medical society museum collection. Since the display of this collection has been put on 'hold,' our committee has not had anymore meetings and I think this would be a good opportunity to update the members of the committee on the collection."[15]

The committee's vision differed from the SLSC's overarching vision, which was to use interactive exhibits, coupled with informal education programs, to make science interesting and understandable to the public; components of the collection were to be pieced together to create medical technology exhibits. Quoting the 1988 SLSC Annual Report: "The 'Medical Technology' exhibit compares and contrasts past and present methods of diagnosis. The exhibit also identifies trends that may affect medical technology in the future and emphasizes local and regional advances in medical technology research and development."[16]

We have been unable to find further minutes for the advisory committees. Coxe resigned on March 31, 1987, but continued her inventory of museum artifacts in a volunteer capacity and completed this on November 6, 1987. Her final inventory count was 11,920. Ronald Beer replaced Coxe soon after.[17] Sometime in 1987, a SLSC Medical Technology Committee, populated by SLSC staff rather than SLMMS physicians, developed a draft exhibit outline.[18] The Medical Society advisory committee appears to have either been inactive or was dissolved after 1987.

## Saint Louis Science Center: Med Tech Gallery and Inside the Vault

The plan to repurpose the Falstaff building was formally dropped by the end of 1986. A master plan which outlined a new building and detailed major exhibits was begun in early 1987 and was completed in December 1987.[17] The Capital Campaign for this project was announced in 1988. The Falstaff building was purchased outright in early 1989, and demolition began in June of that year. A beautiful new building was erected at 5050 Oakland Avenue, and it opened its doors to the public on November 2, 1991. The ~700-foot long Skybridge crossing Highway 40 was built and it merges into an ~360-foot tunnel connecting it to the lower level of the Planetarium.

One of us (KH), hired as the SLSC Manager of Collections & Special Projects/Exhibits in 2013, provides the next parts of the story. One of the first major exhibits in the SLSC complex was the Med Tech gallery, located in the tunnel leading to the Planetarium. It included more than 300 SLMMS artifacts like the iron lung, pharmacy cabinets full of historic drug jars, and some of the medical quackery items, but was also interactive—letting visitors take their weight, height, and blood pressure, listen through a stethoscope, look through an endoscope, and tap on drum "cavities" to listen for fluid (Figure 4). With a renovation of the Planetarium and tunnel scheduled to begin in 2000, the entire Med Tech gallery was moved to the first floor of the new 5050 building in August, replacing a portion of another popular exhibit called Human Adventure. The new combined Human Adventure and Med Tech gallery opened in late October 2000 and remained the most popular exhibit in the SLSC until it was removed in 2010.

Over the years, there have been other exhibits featuring objects from the SLMMS collection displayed in the SLSC. One example would be a 2010-2011 exhibit on the Civil War which featured medical tools







Figure 4. Above: Entrance to Med Tech Gallery in the tunnel, circa 1996. Below: Med Tech interactive exhibits as well as quackery display case (center) and iron lung (back left corner). *Courtesy of the Saint Louis Science Center.*

and equipment from that time. The SLSC also loans objects from the collections to other institutions.

In 2021, the SLSC opened an exhibit entitled "Inside the Vault," where thematic displays are produced from artifacts in the collections. The current iteration, which was installed in December 2024 and expected to remain in place until the end of 2026, features nearly half of the quackery artifacts acquired with the SLMMS collection (Figure 5). Seeing these is a bargain, as the SLSC remains one of very few science museums in America with free entry.




Figure 5. Saint Louis Science Center Inside the Vault exhibit of quackery artifacts. *Courtesy of the Saint Louis Science Center.*

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## Disclosure

A longer version of this paper with more historic details, references, and figures can be accessed online at: https://www.slsc.org/st-louis-metropolitan-medical-societys-medical-historical-museum-national-museum-of-quackery-1964-1984/ **MM**

# My Full Circle Journey and Why Communication, Mentorship, and Service Matter So Deeply

*by Ravi Johar, MD*

***"Regardless of whether physicians practiced in rural or urban settings, large systems or small practices, in insurance, or academics, or politics, all shared the same fundamental goal: to take care of patients.***

From an early age, medicine felt less like a conscious choice and more like a natural extension of who I was. My parents liked to remind me of a photograph taken when I was about four-years old, in which I am carefully examining a doll with a toy stethoscope, wearing the kind of seriousness only a child can muster.

They often said that was the moment they first believed I might one day become a physician. For a first-generation immigrant family—where the aspirational paths often felt narrowed to "engineer or doctor"—that realization brought them a particular kind of pride. In time, one of my brothers also became a physician, while another pursued a career in electrical engineering, and in many ways we fulfilled the familiar narrative of an immigrant household navigating opportunity in America.

I grew up in Wayne, Nebraska, a small town in the northeastern corner of the state. Life in a small community offered an environment where curiosity could flourish. I was endlessly interested in how things worked, why they worked, and how they might work better. That inclination toward analysis, combined with a growing love of communication, eventually led me to speech and debate in high school. The experience proved formative. It taught me the power of explanation, the value of dialogue, and the responsibility that comes with persuasion. Those early lessons would later shape how I practice medicine and how I lead within it.



Four-year old future Dr. Johar beginning his medical journey.

In college, I continued competing in speech and debate while also serving as a teaching assistant for pre-med biology courses. Teaching proved unexpectedly rewarding. I discovered how much I enjoyed helping others grasp complex concepts and watching understanding take shape through conversation and explanation. That commitment to education and clear communication became a consistent thread throughout my career. Although I entered college as a chemistry major, an honors chemistry course quickly revealed that my academic interests were broader and more interdisciplinary than I had anticipated. I loved the sciences—chemistry and biology—but I was equally drawn to literature and became deeply captivated by political science. Ultimately, I completed a major in Political Science with minors in Chemistry, Biology,



**Ravi Johar, MD**, is a Board Certified Obstetrician/Gynecologist who has practiced in St. Louis Missouri area for 35 years. He is Past President of the Missouri State Medical Association and has been active in organized medicine throughout his career.

and English. That combination reflected both my intellectual curiosity and my growing belief that medicine benefits greatly from perspectives beyond the laboratory and clinic.

I was fortunate to be accepted to the University of Nebraska College of Medicine (UNMC) and moved to Omaha to begin medical school, which proved to be every bit as challenging as I had been warned. There were many moments when I questioned whether I had made the right decision. I know I drove my father crazy with those doubts, and he often reminded me—sometimes patiently, sometimes less so—that this path had been one that I had wanted since I was four-years old and to just stick with it. And of course, as Dads usually are, he was right. He truly was an incredible man and shaped me into who I am today.



Kay Johar, PharmD and Ravi Johar, MD, on their wedding day.

During medical school, I became involved in organized medicine for the first time. I joined the American Medical Student Association and eventually served as president of AMSA at UNMC. Later, I was selected as a national officer. Through this involvement, I made my first of many trips to Washington, DC—experiences that would have a lasting influence on the direction of my career. My early exposure to the legislative process was exciting, energizing, and eye-opening. I quickly realized how limited the understanding of healthcare issues often was among legislative aides and policymakers. I found myself explaining concepts that medical students and physicians took for granted, trying to translate lived clinical experience into language that resonated beyond medicine.

That intersection of medicine, policy, and communication deeply appealed to me and has continued to shape my professional life.

During my final years of medical school, clinical rotations exposed me to a wide range of specialties. Much to my surprise, I discovered that I absolutely loved Obstetrics and Gynecology. When I began medical school, I was convinced there were three specialties I would never consider, and OB-GYN was one of them. Yet as I rotated through the specialty, I found it exhilarating. It felt like one of the few places in medicine where patients genuinely wanted to go to the doctor or come to the hospital. In a single day, you could guide someone through different stages of pregnancy, perform surgeries, help patients struggling with infertility, manage complex bleeding disorders, provide contraception, and much more. No two days were alike. Most importantly, OB-GYN offered the opportunity to develop long-term, meaningful relationships with patients during some of the most significant moments of their lives. I realized this was what I wanted to do for the rest of my career.

I was fortunate to match for residency at the Medical College of Georgia in Augusta, Georgia. My very first rotation was in the neonatal intensive care unit. Learning to give micro-doses of medications to fragile newborns was intimidating, to say the least. That intimidation intensified when I encountered the Supervisor of the Pediatric pharmacy, someone who seemed to know the answer to every question. In a gentle Southern voice, she would ask residents whether they were absolutely certain they wanted to give what she suggested might be a harmful dose of medication to a newborn. To say I was intimidated by this brilliant, confident woman would be an understatement.

A medical student rotating with me noticed something else, however, and insisted that I ask the pharmacist out. I did, and it turned out to be the best decision of my life. Kay and I have now been married for 34 years, a partnership that has shaped every part of my personal and professional journey.

After residency, Kay and I explored a number of job opportunities and ultimately decided to move to St. Louis, Missouri. St. Louis was geographically halfway between her family in Kentucky and mine in Nebraska, and it was also home to outstanding children's hospitals where Kay could continue her career as a pediatric pharmacist. In fact, she was offered a position at St. Louis Children's Hospital before I had secured a job of my own.

During my first year in practice, we were blessed with the first of our three incredible children, Katelyn, who is now a Speech Language Pathologist in St. Louis. Kay chose to take a sabbatical to care for her—a sabbatical that has now lasted more than 33 years and grown to include two more children, Alex, a Urology Resident in Omaha, Nebraska, and Megan, a Digital Strategist/Computer Engineer working on Generative AI for ThermoFisher Scientific in Louisville, Kentucky. I am beginning to think that this sabbatical may be permanent.



SLMMS President Laurin Council, MD, presents the Schlueter Award to Dr. Johar.



The Johar family: From L to R, Dr. Jassi Johar (Ravi's younger brother), Dr. Alex Johar (Ravi's son), Mrs. Manjit Johar (Ravi's Mother), Ravi Johar, MD, Kay Johar (Ravi's wife, Pediatric PharmD), Katelyn Johar (Ravi's oldest daughter), Megan Johar (Ravi's youngest daughter.

Early in my career, I received a call from Gordon Goldman, MD, a past president of the Missouri State Medical Association, asking me to consider serving on the St. Louis Metropolitan Medical Society (SLMMS) Council. While I had been involved in organized medicine during medical school, I had drifted away during residency. That call reignited my connection to the broader House of Medicine. I was immediately captivated by the passion, dedication, and sense of purpose I observed at the Council level. I remained involved, moved through leadership roles, and ultimately served as President of SLMMS in 2006. I have remained actively involved ever since, chairing committees and participating in strategic planning. I continue to serve as the Nominating Committee Chair and mentor emerging physician leaders. I was deeply honored in 2024 to receive the Schlueter Award from SLMMS.

I learned that this is considered the highest honor the Society can bestow and has only been presented 21 times in its 187-year history. To receive this from my colleagues for doing things I loved was truly humbling.

Following my year as SLMMS President, an opening arose on the MSMA Council. I was elected by my colleagues to serve as Vice -Councilor and later as Councilor, eventually becoming President in 2016. MSMA aligned perfectly with what I loved most about organized medicine, particularly its legislative engagement. Through MSMA and in collaboration with the American Medical Assocation (AMA), I had additional opportunities to lobby on Capitol Hill. I eventually joined the AMA delegation, serving first as an Alternate Delegate and now as a Delegate from Missouri.

Working alongside leaders such as. David Barbe, MD, provided invaluable insight into how organized medicine functions at the national level. I have been honored to continue serving as MSMA's legislative chair, a role that fits naturally with my background in policy, education, and communication.

In parallel, I have remained deeply involved with my specialty society, the American College of Obstetricians and Gynecologists (ACOG). My involvement with ACOG began during residency and expanded over time. Within Missouri, I served on the Section Advisory Council and later as chair of the Missouri Section. I went on to serve as District 7 legislative chair, helping coordinate advocacy efforts across a nine-state region. These experiences reinforced my belief in the importance of collaboration between specialty societies and the broader House of Medicine.

During my term as MSMA president, I had the privilege of meeting with physicians and organizations throughout Missouri, neighboring states, and across the country. One truth became abundantly clear: being a physician is not simply a job—it is an identity. Regardless of whether physicians practiced in rural or urban settings, large systems or small practices, in insurance, or academics, or politics, all shared the same fundamental goal: to take care of patients. What varied was the degree to which physicians understood how interdependent we are on one another. The ability to care for patients depends not only on individual clinicians, but on the collective efforts of physicians fulfilling many different roles within medicine. Once again, communication—and a shared understanding of how interconnected we are—emerged as a critical theme. I found myself wondering how I could help with this understanding.




Cover of the May./June 2015 *Missouri Medicine* showing Dr. Johar watching Governor Nixon sign the Tort Reform Bill.



Passing the torch to the next generation. Dr. Johar with son, Alex, as he began Medical School at Creighton University School of Medicine.

Coincidentally around that same time a perfect solution presented itself. I was approached with the possibility of a career transition and ultimately moved from private practice into the role of Chief Medical Officer for UnitedHealthcare. While initially surprising to some colleagues, the role has allowed me to serve as a problem solver rather than a gatekeeper. My work does not involve utilization management or denials. Instead, it focuses on identifying problems—both individual and systemic—and working collaboratively to address them. Being able to help patients access the care they need, while also improving processes for those who will follow, has been deeply gratifying. Earning the trust of colleagues and working together to find solutions to physician concerns is what I find most rewarding about this chapter of my career.

In addition to the gratification I have received in my professional career, I have had the opportunity to become very involved in my community in both health-related and non-health related activities. Serving on the Board of the American Heart Association, United Cerebral Palsy, and the St. Louis County Board of Public Health has been personally gratifying and I hope contributed to the health of our community.

Personally, I have received tremendous satisfaction from serving with the Boy Scouts. I have had the privilege of serving as Scoutmaster for Troop 809 while my son was getting his Eagle and had the opportunity to join him as we both achieved the Grand Slam of Scouting, which is participating in all four High Adventure Camps that Scouting America offers. Just when I was thinking of retiring from Scouting, I was asked to serve as the District Chair for the New Horizons District in St. Louis County, which just happens to be the largest district in Scouting in the entire country.

Looking back, a common thread runs throughout my professional and personal life: helping people understand complex issues and move forward with clarity. From my early days as a teaching assistant, through residency, legislative advocacy, patient care, leadership and community service, that purpose has remained constant.

Most recently, mentoring my son as he navigates his own medical career as a urologic surgery resident has been among the most gratifying experiences of my life—one that brings my journey full circle and reminds me why communication, mentorship, and service matter so deeply. **MM**

# As Rural Hospitals Close, Here's What Integration Has Made Possible in Jefferson City

*by Randall Haight, MD*

Across Missouri, the story is becoming painfully familiar. Community hospitals close. Emergency departments go dark. Physicians are forced to make difficult decisions about whether they can continue practicing where they are most needed. Over the past decade, 21 hospitals in our state have shut their doors, including facilities in Fulton, Mexico, and Boonville. Each closure leaves patients traveling farther for care and physicians practicing with fewer resources, less backup and growing uncertainty.

Against that backdrop, this past January marked the second anniversary of Capital Region Medical Center's integration with University of Missouri Health Care. For those of us practicing medicine in community and rural settings, this milestone offers an important case study in how integration with an academic health center can help stabilize care, expand services and support physicians while keeping care local.

As Capital Region's longtime chief medical officer in Jefferson City, I was optimistic but realistic when integration was first proposed. Physicians naturally worry about whether integration will preserve local access, clinical autonomy and the community mission that defines smaller hospitals.

Two years later, I believe integration has strengthened our ability to practice medicine in Jefferson City.

Clinically, integration has allowed us to add services that would have been difficult to sustain independently. Expanded urgent care and quick care locations with longer hours help relieve pressure on emergency departments and improve continuity of care. Our Missouri Orthopaedic Institute attached to Capital Region Medical Center now offers early-morning walk-in sports injury care, giving families and athletes timely access without leaving the community.

In emergency medicine, integration enabled us to redesign care delivery, add an observation unit and significantly improve throughput. These improvements resulted in shorter wait times, better patient flow, and recognition with the Missouri Hospital Association's "Aim for Excellence Award." For physicians, these operational changes translate directly into safer, more efficient practice environments.

Perhaps most critical in the context of hospital closures is our ability to keep higher-acuity care local. Integration allowed us to expand from 82 to 120 beds, add more than 100 positions and staff Capital Region Medical Center with intensivists. Patients who once would have required transfer to Columbia can now receive advanced care close to home.



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Integration has also expanded specialty access in outpatient settings. Services such as weight-loss surgery, comprehensive spine care and advanced cardiology—including complex pulmonary thrombectomy—are now available locally. Through academic collaboration, we became the first site in central Missouri to use a radioisotope developed at the MU Research Reactor to more accurately assess cardiac blood flow, supporting better diagnosis and treatment without patients leaving the region.

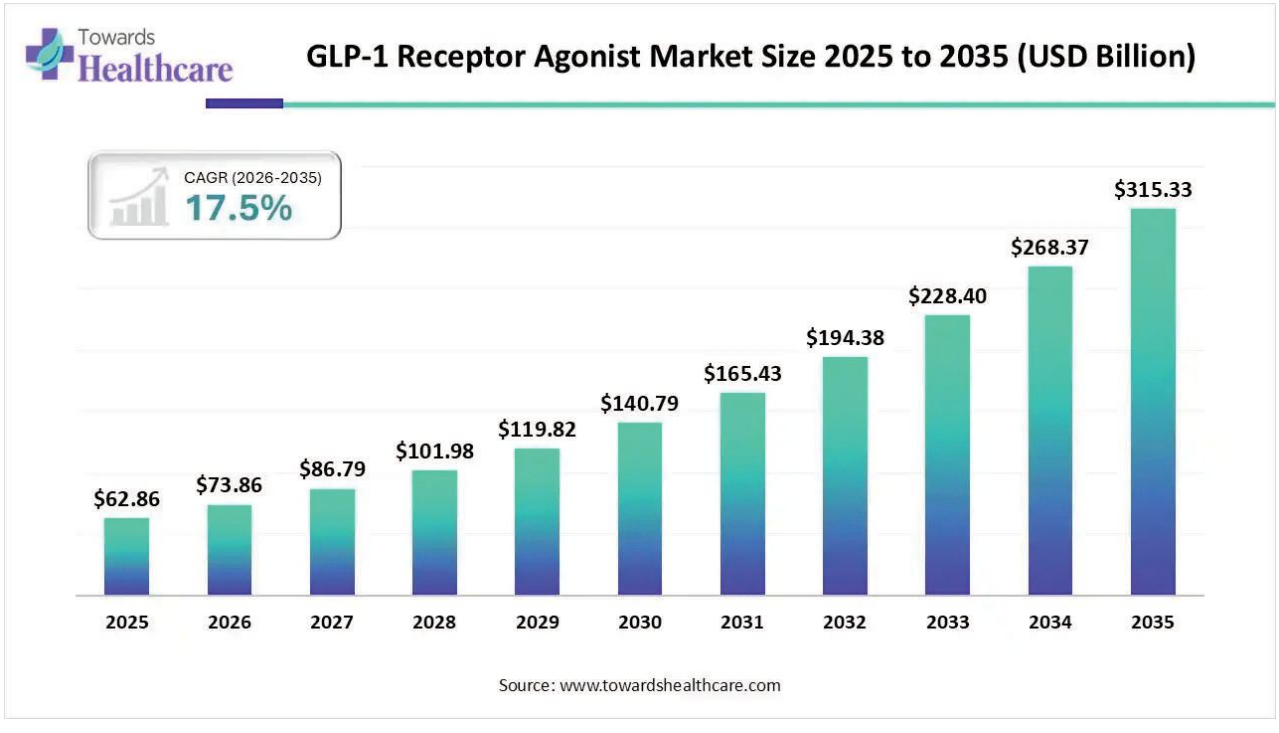
As pharmacies have closed across central Missouri, MU Health Care's investment in retail pharmacies within our Jefferson City and Versailles Family Medicine Clinics have improved medication access and reduced barriers for rural patients managing chronic conditions.

While hospital closures dominate headlines, the more meaningful story may be what integration makes possible over the long term. Being part of the state's flagship academic health system provides community hospitals with physician recruitment pipelines, specialty collaboration, research-driven innovation and financial stewardship that standalone facilities increasingly struggle to maintain.

For physicians, integration is not about losing local identity. It is about gaining support. It is about having access to specialists, technology and infrastructure that allow us to practice at the top of our license while continuing to serve the communities that rely on us.

In an era when rural and community hospitals are disappearing, integration with an academic health center offers one viable path forward. At Capital Region, it has allowed us to preserve access, strengthen physician practice and ensure that high-quality care remains available in Jefferson City for future generations. **MM**

## 1 Picture = 1,000 Words



# Goodbye JoE

*by David A. Fleming, MD*

***"I share your hope as we both understand that we aren't a profession without our ethics."***

The American Medical Association (AMA) announced termination of its online *Journal of Ethics* (*JoE*) after December 2025. This announcement was both surprising and unexpected.

Matt Wynia, MD, MPH, Director of the Center for Bioethics and Humanities at the University of Colorado's Anschutz Medical Campus and former Director of AMA's Institute on Ethics, stated that *JoE* was the brainchild of Audiey Kao, MD, PhD, Vice President of Ethics at the AMA, who transformed the online resource, Virtual Mentor, into a more broadly focused online journal to serve the needs of students and trainees.

*JoE* was founded in 1999 as a free peer-reviewed open access journal published monthly in digital format (https://journalofethics.ama-assn.org/about). It is unique as an online publishing venue that is primarily devoted to promoting students and trainees by encouraging them to compete for opportunities to edit and provide content to themed issues that explore a wide variety of ethical issues. Themed topics provide commentary and case discussions in health humanities, medical education, health policy and equity discussions, social and cultural context perspectives, journal-based and multimedia continuing education materials, visuals, and more. In 2024, the journal received more than 3.1 million visits to its website, more than 125,000 PDF downloads, and more than 37,000 podcast downloads. That website now leads with the statement, "After more than 25 years, the AMA *Journal of Ethics* will cease publishing new content after December 2025."

Justification for eliminating the journal remains a mystery. AMA has offered no comment publicly. If the reasons are financial, *JoE* has been a service to members and health professionals a large and was never intended to generate revenue for AMA. The site has no ads, no subscription fees, and no publication fees. As an ethics journal, market driven conflicts of interest are appropriately avoided.

For AMA as a professional membership organization, however, finances are naturally a concern. AMA's 2024 Annual Report indicates that publishing, which generates about 12 percent of the organization's total revenue, decreased by $2.1 million that year, largely due to a decline in print advertising in *JAMA*, *JAMA Network Open*, and other specialty journals. But JoE has always been online-only, free, and without advertising. In contrast, the *AMA Journal of Ethics*, however was prolific in 2024, publishing 140 articles, reviews and editorials; and it received more than 3.1 million website hits that year.

This is a tremendous loss to our members and the medical profession who enjoyed cost-free access to an organizationally-dedicated site for discussion on ethically-challenging topics in health care; and in offering a conduit of professional growth and development for students, trainees, and young physicians who sought writing and publishing as a way of contributing to these important discussions regionally and nationally.

In a recent editorial Audiey Kao offers his journal's farewell with typical grace: "I want to extend my deepest thanks to the many authors, artists, peer reviewers, editorial board members, theme issue editors and fellows, and staff colleagues who have dedicated their time and talents to advance the *AMA Journal of Ethics*' editorial mission of "illuminating the art of medicine." I will be forever grateful for your kindness and contributions."

In recent personal communication, Dr. Kao adds: "I share your hope as we both understand that we aren't a profession without our ethics." One can only hope that AMA leadership, in manifesting its traditional wisdom, will revisit the question and reignite *JoE* in its present or other form that will encourage ethical debate and represent professional values traditionally held by AMA and the medical profession. **MM**



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# Old Age Will Be Different in the Robotic Age

*by Lydia S. Dugdale, MD*

America faces an eldercare crisis. We have a rapidly aging population, a declining birthrate, and a caregiving workforce that is burning out and increasingly facing deportation. From 2023 to 2024, the number of adults 65 and older grew by 3.1% while the number of children under 18 shrank. In nearly half of US counties, seniors outnumber children. Half of Americans 65 and older have nothing at all saved for future living assistance. We must start thinking about who will take care of grandma and grandpa.



For most families, outsourcing eldercare is prohibitively expensive—upward of $75,000 a year for a home health aide and well over $100,000 for a nursing home. Only when assets run down will Medicaid start footing the bill, though many wrongly assume Medicare will help. Nearly a third of Americans 65 and older live alone. I believe that robots will assume the care of many of them.

A robot would ideally be a one-time expense, requiring minimal maintenance and receiving updates through cloud-computing technology. A limited number of friends and relatives would struggle to provide unpaid stopgap care to aging adults. By contrast, a robot could function around the clock. I've treated elderly patients who had been found wandering the streets, lying in their own excrement, or simply dehydrated because of gaps in care. A tireless robot—made possible through gains in battery life and the ability to self-charge—could mitigate such problems. But robot caregivers leave all of us with ethical questions.

Robot-led eldercare could further isolate seniors who might be better served by community activities in an assisted-living or nursing home. Although social isolation remains a real problem, robots need not mean loneliness. Reliable robotic companions could accompany seniors outside the home for strolls or to community events. They could enhance, rather than diminish, socialization.

And while actual human contact is preferable, it has real drawbacks. Human caregivers can lose their tempers, but robots are unlikely to have that problem. In one recent study, observers found artificial-intelligence-generated responses to be more empathetic, validating, and compassionate than those of humans. A robot with AI-assisted voice technology could potentially understand emotion and intent, clarify instructions, and respond to commands in real time.

But where does this lead us? If I know that grandma has her bot, will I opt not to drop by after work when I'm exhausted? Will the neighbors stop checking on her? As her faculties dwindle, will she feel more at ease with the robot than with her family? Robots may threaten ordinary human interactions while obfuscating what it means to be human. They will take the role of nurses and aides and in some cases provide the emotional support that used to come from family and friends. This runs a real risk of undercutting part of our humanity.



Lydia S. Dugdale, MD, is a physician and ethicist at Columbia University and the author of "The Lost Art of Dying: Reviving Forgotten Wisdom." Reprinted with permission *Wall Street Journal.*

Robots might seem like inhumane stopgaps to care for aging elders, but once this technology proves itself, it will present genuine solutions to crises of affordability, reliability and access. Its advantages over human caregivers, who are expensive and whose numbers are insufficient, will be real and important.

This all may sound like science fiction, but I don't think it is. New Amazon robots have an incredibly fine sense of touch and can pick up objects with precisely the right amount of pressure. Tesla's humanoid robots can now accomplish more than 1,500 tasks, their hands capable of executing 60 of the 100 distinct movements the human hand can perform. Elon Musk projects they will be available in 2026, although he's been wrong in the past and recently lost top robotics talent. But if robots can now fold laundry, serve food, sweep the floor, operate computers, talk, walk and dance, it's plausible that soon they will help our elders out of bed and give them sponge baths. One estimate places the cost of such a humanoid robot at $20,000—not bad compared with a nursing home.

As someone with Luddite tendencies, I still find the whole idea a bit absurd. Science fiction has been making promises and issuing warnings about humanoid machines since before the Czech writer Karel Čapek introduced the word "robot" in a 1920 play. Care-giving robots still seem too futuristic or clunky to be of real value. Previous attempts have ended in failure. Maybe the next one will, too. But we are getting closer, and I think I'll soon be writing prescriptions for eldercare robots.

This will present humans with real choices. The original Luddites—English textile workers who objected to mechanical looms and destroyed them in protest—believed they were fighting for their very existence. Robot caregivers may force a similar reckoning. But rather than destroying robots in protest, we must keep them in their rightful place.

Čapek's word "robot" came from the Czech for "forced labor." The term gives us a direction: Designing robots to labor for us, programming them to treat humans with compassion. That is our decision as their creators. By contrast, we human beings aren't programmed but free. We must choose to be kind and compassionate to one another. The introduction of robotic caregivers doesn't nullify this responsibility but makes it more urgent. **MM**



# Robotics in Cerebrovascular Disease: The Final Frontier

*by Ibrahim A. Bhatti, MD, Hunter Brooks, MS, Fareed Jumah, MD, Balint Otvos, MD, Camilo Gomez, MD, Adnan I. Qureshi, MD & Farhan Siddiq, MD*

Health Care

**Robotics in neuroendovascular surgery is evolving from a novel adjunct to clinical reality.**



Ibrahim A. Bhatti, MD, Hunter Brooks, MS, Fareed Jumah, MD, Balint Otvos, MD, and Farhan Siddiq, MD, (pictured), are in the Department of Neurosurgery, University of Missouri, Columbia, Missouri, USA. Camilo Gomez, MD, MBA, and Adnan I. Qureshi, MD, are in the Department of Neurology, University of Missouri, Columbia, Missouri, USA. Dr. Qureshi is also at the Zeenat Qureshi Stroke Institute, Columbia, Missouri, USA.

## Abstract

**Cerebrovascular disease remains a leading cause of global mortality. While endovascular therapies like mechanical thrombectomy and aneurysm coiling have revolutionized management, manual techniques are limited by operator fatigue, tremor, and occupational radiation exposure. This review examines the current state of robotics in neuroendovascular surgery. FDA-approved systems demonstrate safety and technical feasibility, achieving high success rates (94–100%) in aneurysm coiling and carotid stenting while significantly reducing operator radiation exposure (60–80%). In ischemic stroke, preclinical and recent clinical milestones, including the first fully remote, in-human diagnostic angiogram and transcontinental thrombectomy simulations, validate the feasibility of long-distance tele-interventions. Robotics in cerebrovascular management is rapidly evolving from a novel adjunct to clinical reality. Although challenges regarding cost, haptic feedback, and training persist, next-generation platforms integrating artificial intelligence and magnetic navigation hold the potential to overcome these barriers, establishing remote telerobotic networks to expand access to time-critical stroke care.**

## Key Words

Cerebrovascular disease, robotics, neuroendovascular surgery, stroke.

## Introduction

Stroke is a leading cause of disability and mortality worldwide, and the fifth most common cause of mortality in the United States.[1] Strokes are broadly classified into hemorrhagic and ischemic. With an aging population and increasing prevalence of risk factors, the incidence of cerebrovascular disease is expected to rise.[2] Despite significant progress in prevention and treatment over the past 20 years, cerebrovascular disease continues to place a heavy burden on the healthcare system.[3] Over the past decade, the integration of artificial intelligence (AI) in medicine, particularly in cerebrovascular interventions, has grown rapidly.[4]

Unlike AI, robotics in endovascular surgery is still in its relative infancy. Surgical robotic systems are typically classified into active, semi-active, and surgeon-controlled systems. Current endovascular robotic systems are surgeon-controlled, featuring a

patient-side robot and a radiation-shielded control station.[5] Interventional cardiology has successfully demonstrated the safety and efficacy of robotics.[6,7] Interventional neuroradiology is following in pursuit, with perceived benefits including reduced physician radiation exposure, increased procedural efficacy, and improved safety.[8] This review explores the current prospects of robotic surgery in neuroendovascular procedures.

## Cerebrovascular Diseases and Current Surgical Management

Ischemic strokes, caused by thromboembolic large vessel occlusions (LVO), account for 30% of strokes and are managed with mechanical thrombectomy (MT) as the gold standard. Landmark trials (e.g., DAWN, DEFUSE-3, SELECT-2) have established the efficacy of MT in salvaging penumbral tissue across various time windows and infarct sizes.[9,10] Hemorrhagic disease management has similarly evolved toward endovascular therapy (EVT). For intracranial aneurysms, less invasive techniques such as coil embolization, flow diverters, and intrasaccular flow disruptors have largely superseded open surgical clipping.[9,11]

For arteriovenous malformations (AVMs), transvenous embolization has emerged as a significant tool, often followed by radiation.[9] Similarly, intracranial atherosclerotic disease (ICAD) has seen revived interest in stenting with drug-eluting stents (DES) to reduce recurrence.[9,12]

Despite EVT dominance, craniotomy remains pivotal for malignant middle cerebral artery (MCA) infarctions,[13,14] wide-neck aneurysms,[15] and low-grade AVMs.[16] Post-acute long-term recovery relies on neuroplasticity-driven rehabilitation, a labor-intensive process where robotic assistance could standardize care.[17,18]

## Current Challenges with Contemporary Techniques

Existing endovascular techniques face challenges in navigating complex geometries and atherosclerotic vessels, with manual manipulation risking vessel perforation or dissection.[19,20] Robotics offer enhanced precision, improved dexterity, and elimination of physiological tremors.[21] Furthermore, manual EVT exposes operators to radiation and orthopedic strain from lead aprons, increasing risks for cataracts, spinal degeneration, and brain cancer.[4,21-24] Teleoperated robotic systems like the CorPath GRX allow operators to remotely control catheters from shielded consoles, mitigating these occupational hazards and potentially lowering barriers for women in neurointervention.[25]

Scaling EVT access is also challenging; nearly half of the US population lives over an hour from comprehensive stroke centers. Teleoperated robotics could extend high-quality stroke interventions to remote hospitals, overcoming geographic constraints.[26]

## Current Applications of Robotics in Medicine

Robotics in medicine began with CT-guided brain biopsies over 30 years ago.[27] Today, systems like da Vinci are used in millions of procedures, offering smaller incisions and quicker recovery.[27] In cardiology, large trials confirming safety and efficacy paved the way for neuroendovascular integration.[28] Robotic assistance is now widely adopted in urology, gynecology, and general surgery,[29] demonstrating clear advantages such as 3D visualization, tremor elimination, and reduced postoperative complications.

## Endovascular Robotic Systems and Technical Features

Current neuroendovascular robotic systems consist of a patient-side mechanical robot and an operator control station equipped with high-resolution monitors and joysticks. The robot maneuvers catheters via friction rollers, linear clamps, or magnetic fields.[30-32] The CorPath GRX, widely used for coronary and peripheral interventions, offers robotic control of guide catheters. However, its initial neurovascular use revealed complications like microcatheter herniation, prompting design updates.[5] To address hardware limitations, newer systems like the PANVIS-A have been introduced with a "catheter-on-finger" interface designed to mimic the tactile spatial setup of manual guidewire manipulation.[33] A randomized controlled trial comparing PANVIS-A to manual neurointervention demonstrated 100%

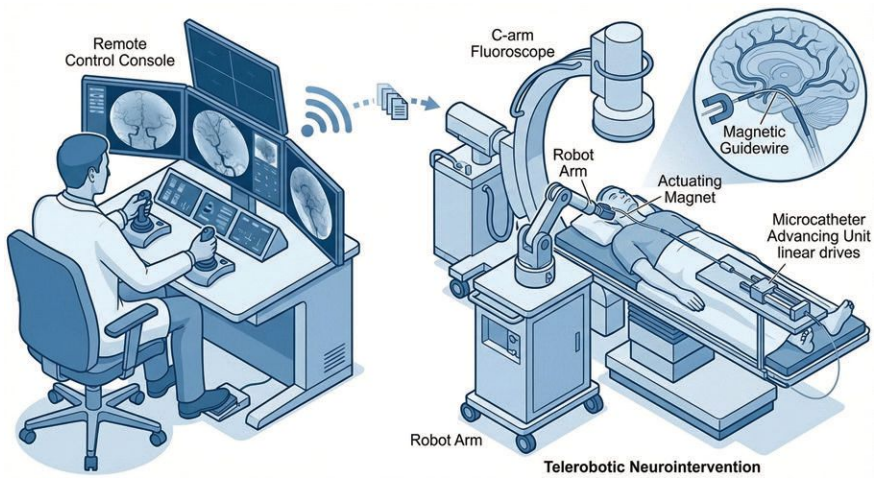



Figure 1. Schematic of the telerobotic neurointerventional platform. The system connects a remote control console at a comprehensive stroke center (left) to a patient-side setup at a rural hospital (right) via a wireless network. The interventionalist controls the procedure using joysticks and a fluoroscopy foot pedal while monitoring real-time imaging. The bedside unit includes a C-arm fluoroscope, a motorized microcatheter advancing unit with linear drives, and a robotic arm. The robot arm positions an actuating magnet to remotely steer a magnetic guidewire through the patient's cerebral vasculature (inset).

technical success in both arms, with the robotic group experiencing significantly reduced operator radiation exposure (1.67 ± 3.49 μSv vs 43.63 ± 38.95 μSv, P < 0.001).[33]

## Mechanical Thrombectomy for Ischemic Stroke

Robotic utilization in MT remains limited, partly because current systems like CorPath GRX cannot easily control triaxial catheter systems or navigate the supra-aortic trunks.[5,34] However, preclinical studies in 3D-printed neurovascular models have shown higher first-pass recanalization rates for robot-assisted groups compared to manual thrombectomy (89.2% vs. 71.1%).[34] Animal and cadaveric studies confirm the technical feasibility of remote robotic navigation into cerebral vessels, showing promise for standardizing repetitive tasks and reducing procedure times.[35]

## Aneurysm and AVM Treatment

The CorPath GRX has been extensively studied for aneurysm treatment. Following the first-in-human robotic stent-assisted coiling of a basilar aneurysm in 2020,[36] multicenter studies have demonstrated high technical success rates (~94%) without unplanned manual conversion, comparable to manual coiling trials.[37] Single-center studies similarly report 100% technical success and durable occlusion in stent-assisted coiling and flow diversion.[38-40] Despite procedural similarities, clinical experience with robotic AVM embolization remains absent in current literature.

## Carotid Stenting

Robotic carotid artery stenting (CAS) has been evaluated using CorPath GRX and Magellan systems, demonstrating 100% technical success in transradial procedures with equivalent complication rates to manual approaches.[41-43] Although procedure times are initially longer, they improve after a learning curve of 10–20 cases.[41,42]

## Robotic-Assisted Open Neurosurgical Treatment

In neurosurgery, robotic assistance typically refers to stereotactic workflow systems for trajectory planning in applications like deep brain stimulation (DBS) and stereo-electroencephalography (SEEG).[44,45] Telesurgical systems like da Vinci remain uncommon in routine practice due to instrument mismatches and workflow limitations and a comparatively limited clinical evidence base.[46]

## Rehabilitation Robotics

Rehabilitation robotics utilize electromechanical devices for task-specific motor recovery training. Lower-limb platforms significantly increase the likelihood of independent walking after stroke (OR 1.94, p < 0.001).[47] Subacute stroke patients show measurable improvements in functional ambulation, balance, and mobility, though overall walking velocity changes may not be statistically significant.[48] For upper-limb rehabilitation, robotic therapy yields

modest immediate gains in motor impairment (Fugl-Meyer scores) and daily function (Modified Barthel Index), though long-term differences from conventional therapy vary.[49] Overall, robotics effectively augment therapy intensity and standardization.

## Advantages of Robotics in Cerebrovascular Treatment

Robotic endovascular systems provide submillimeter control of microcatheters, offering tremor-free manipulation vital for stent-assisted coiling and flow diversion.[36-38] These systems may facilitate further miniaturization of procedural access, reducing tissue trauma.[37,39] Crucially, remote workstations reduce operator radiation exposure by 60–80% without compromising efficacy, alleviating risks of musculoskeletal injury.[50-52]

## Remote Robotics and Telemedicine

Teleoperated robotic platforms hold transformative promise for expanding access to time-critical stroke care in underserved regions.[35,53] Recent preclinical studies validate the feasibility of fully remote endovascular navigation. Duckwiler et al.[54] demonstrated successful catheter navigation from the femoral artery to the MCA across distances >2500 miles. Automated safety protocols successfully triggered control lockouts during rare latency spikes (>150 ms) to prevent vascular injury. Olson et al[55] reported the first intercontinental simulated stroke thrombectomy (5,700 miles) using an electromagnetic navigation system (Navion 1.2), achieving 100% technical success. Furthermore, the Sentante system executed the first transatlantic remote thrombectomy with haptic feedback, validating long-distance feasibility.[56] Figure 1 shows a schematic of the telerobotic neurointerventional platform.

In August 2025, Unity Health Toronto achieved the world's first remote, robotic-assisted neurovascular diagnostic angiogram. Using the Remedy Robotics N1 system, the operator successfully completed the procedure on a patient located 6 km away. By eliminating the need for a bedside interventionist during the robotic portion, this initiative validates a new paradigm in neurointervention, allowing healthcare systems to virtually bring the specialist to the patient.[57]

## Challenges and Limitations

Robotic endovascular systems entail significant complexity and steep operator learning curves. Current generations largely lack native haptic feedback, relying on visual cues,[5] though emerging platforms are integrating force-feedback technology. Nontrivial integration with existing hospital infrastructure and high prohibitive costs (e.g., $480,000–$650,000 for the CorPath GRX unit plus $300–$750 per single-use cassette) remain substantial barriers.[58,59] Additionally, large randomized controlled trials (RCTs) comparing robotics to conventional procedures are lacking.[21] Ethical and logistical issues, such as liability, interstate teleoperation licensing, and standard training programs, must also be addressed before widespread adoption.[60,61]

## Future Directions

Next-generation robotics will incorporate enhanced haptic feedback, soft continuum robots, and magnetic actuation for improved navigation.[62]AI-driven trajectory planning and real-time imaging fusion will further augment operator decision-making.[53] Multicenter RCTs with longitudinal follow-up and cost-effectiveness analyses are urgently needed to guide evidence-based adoption.[21] Establishing teleoperation networks to bridge urban–rural healthcare divides remains a strategic objective dependent on technological affordability and regulatory harmonization.[53,60]

## Conclusion

Robotics in neuroendovascular surgery is evolving from a novel adjunct to clinical reality. Current systems offer clear benefits, including reduced occupational hazards and submillimeter precision. Despite challenges regarding cost, technical limitations, and regulatory hurdles, recent milestones, such as the first fully remote human diagnostic angiogram and transcontinental thrombectomy simulations, demonstrate immense potential. To realize the life-saving impact of

robotic neurointervention, ongoing research, rigorous clinical trials, and creative delivery models are essential to establish remote telerobotic networks and expand access to care.

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# The Role of Artificial Intelligence in Acute Ischemic Stroke Care: A Narrative Review

*by Hunter Brooks, MS, Zuri St. Julien, BS, Ibrahim A. Bhatti, MD, Balint Otvos, MD, Camilo Gomez, MD, Adnan I. Qureshi, MD & Farhan Siddiq, MD*

Health Care

**Crucially, AI in stroke care functions not as an autonomous clinician but as a validated "second reader," a triage assistant, and a workflow orchestrator, providing support for alert generation, prioritization, and protocol activation.**



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## Abstract

**Acute ischemic stroke remains a leading cause of death and disability; despite time-dependent reperfusion therapies, delays in recognition, imaging interpretation, triage, and specialist access still limit timely treatment. This narrative review outlines how artificial intelligence (AI) may reduce bottlenecks across the stroke pathway.**

**Prehospital tools include dispatcher decision support, consumer wearables, mobile assessment apps, and portable diagnostics may improve early detection and destination selection. In-hospital, AI increasingly assists neuroimaging and workflow, including intracranial hemorrhage detection, automated ASPECTS scoring, large vessel occlusion identification, and perfusion-based estimation of tissue salvageability, often shortening notification and process times. We also discuss AI-enabled risk stratification, systems-of-care coordination, and emerging uses of generative AI for documentation and communication.**

**Key limitations include domain shift, incomplete external validation, bias and equity risks, limited explainability, alert fatigue, integration challenges, and evolving regulatory accountability. Future priorities include multimodal models, prospective implementation-focused trials, and deployment-ready solutions for diverse real-world settings.**

## Key Words

Acute ischemic stroke, artificial intelligence, stroke.

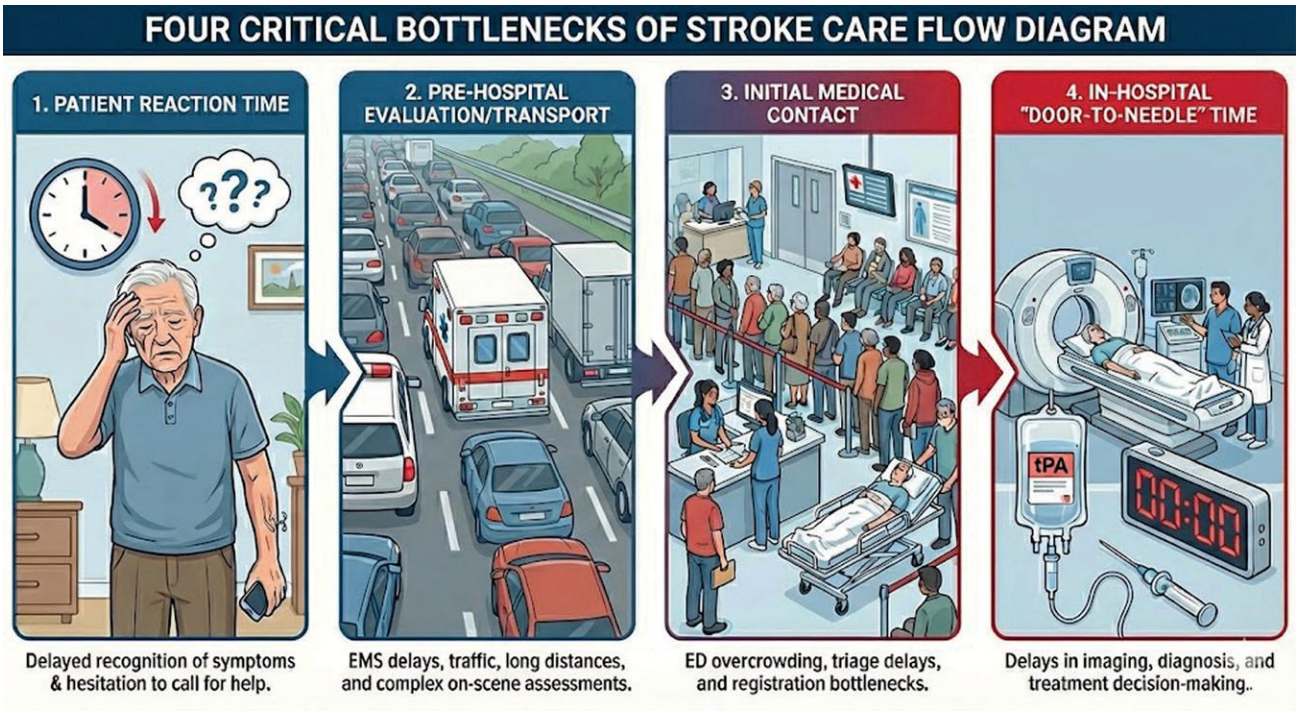
## Introduction: The Imperative for Artificial Intelligence in Modern Stroke Care

### *The Global and National Burden of Stroke*

Stroke remains one of the most formidable challenges in modern medicine. According to the Global Burden of Disease (GBD) 2021 estimates, stroke ranks as the second leading cause of death globally and the third leading cause of combined death and disability, resulting in 7.3 million deaths in 2021 alone.[1] Despite therapeutic advancements, 17.5% of stroke patients still die, positioning stroke as the fifth leading cause of death in the US.[2]

Profound disparities persist across geographic and socioeconomic lines. Mortality rates in low-income countries are 3.6 times higher than in high-income nations.[3] Within the US, Black and Hispanic individuals experience higher incidence rates,

*Figure 1.*




more severe presentations, and poorer outcomes compared with White patients.[4] These inequities highlight the urgent need for scalable solutions capable of bridging the gap between tertiary centers and underserved communities.

### *Pathophysiology: The "Time is Brain" Imperative*

Ischemic stroke constitutes approximately 65.3% of all cases, with hemorrhagic stroke accounting for the remainder,[3] and both resulting in rapid neuronal death driven by oxygen and glucose deprivation.[5] The clinical axiom "time is brain" quantifies this urgency as during an untreated large-vessel occlusion (LVO), the brain loses approximately 1.9 million neurons per minute, translating to an aging acceleration of 3.6 years for every hour treatment is delayed.[6] The underlying mechanism of this loss is the transition of the ischemic 'penumbra' – functionally impaired but structurally intact tissue, into the irreversibly damaged infarct core.[7] This transition is driven by a biochemical cascade: regional blood flow drops below approximately 20 mL/100g/min,[7] leading to depolarization, calcium and sodium ion influx, and the subsequent release of toxic amino acids and free radicals.[8] Cytotoxic edema and proteolytic enzyme activation follow, causing irreversible cell death.[8]

### *Acute Reperfusion Therapies*

The biological target of acute therapy is the penumbra.[7] There are currently two approved methods for reperfusion. Intravenous thrombolysis with alteplase or Tenecteplase [tissue plasminogen activators (tPA)s] is approved within 4.5 hours of symptom onset, and administering treatment beyond this therapeutic window markedly elevates the risk of hemorrhagic complications.[9] Endovascular thrombectomy (EVT) serves as a supplemental or alternative therapy to the tPA agents and can be effective up to 24 hours in select patients with salvageable tissue.[10] This extended window is contingent on identification of the ischemic penumbra in advanced imaging (CT perfusion or MRI), a resource-intensive and variably accessible process.[10] The benefit of reperfusion is strictly time-dependent; every 15-minute delay in treatment reduces the likelihood of a good clinical outcome by 4%,[18] and modern guidelines emphasize a door-to-needle (DTN) benchmark of ≤30 minutes.[11] Despite the known benefits of rapid intervention, systemic barriers prevent many patients from receiving timely care.[12] Current literature identifies four critical bottlenecks: patient reaction time, pre-hospital evaluation/transport, initial medical contact, and in-hospital "door-to-needle" time.[12] (Figure 1).

### *Artificial Intelligence: A Paradigm Shift*

Challenges in delivering rapid acute therapies have motivated growing interest in artificial intelligence (AI) to enhance detection, characterization, and triage of acute stroke across the prehospital and early in-hospital phases. Encompassing machine learning, neural networks, and deep learning techniques, AI has the potential to expedite diagnosis and treatment by standardizing imaging interpretation, improving triage and transfer processes, and enabling predictive risk stratification, thereby helping to reduce geographic and socioeconomic disparities in care.[13]

Machine learning broadly refers to computational methods that learn patterns from structured datasets created by humans. When organized into interconnected layers, these systems form neural networks capable of processing progressively more complex data.[14] Deep learning extends this concept by stacking multiple neural network layers, enabling analysis of highly complex and large-scale datasets, often identifying patterns with minimal human input.[14] The selection of a computational approach depends on the complexity of the clinical problem;[14] for example, detecting intracranial hemorrhage on non-contrast CT may be achieved with traditional machine learning models, whereas predicting stroke outcomes or recurrence typically requires more advanced deep learning techniques.[13]

Crucially, AI in stroke care functions not as an autonomous clinician but as a validated "second reader," a triage assistant, and a workflow orchestrator, providing support for alert generation, prioritization, and protocol activation. This review aims to provide a clinically oriented overview of AI tools across the acute stroke pathway, evaluating current evidence, identifying implementation barriers, and outlining future research priorities.

## AI in Pre-Hospital and Emergency Triage

Artificial intelligence offers substantial advancements in the pre-hospital and emergency triage phases of acute ischemic stroke management, primarily by expediting diagnosis and patient routing to specialized centers.[15] The need for urgent treatment for AIS places significant responsibility on EMS to triage patients to the appropriate facility. Delays are consequential, as up to one-third of LVO cases lose thrombectomy eligibility due to transfer delays.[15] As a result, AI tools that assist EMS providers play a pivotal role in the stroke care pathway.[15]

### *Symptom Onset: Consumer Tech and Dispatcher AI*

AI is increasingly being integrated into the earliest phase of stroke care, the emergency call itself. Speech-based dispatcher assessment, traditionally reliant on human application of rule-based algorithms, is now being transformed by Large Language Models (LLMs). These systems enable real-time translation to overcome language barriers and analyze caller speech patterns to identify stroke probability.[16] Furthermore, predictive dispatch modeling integrates electronic health records, real-time GPS vehicle positioning, and demand forecasting to optimize ambulance deployment.[17]

### *EMS On-Scene Assessment: Apps and Algorithms*

Once EMS arrives, mobile applications leveraging smartphone cameras and microphones facilitate early symptom detection. These tools typically combine computer vision (for facial asymmetry and limb movement) and speech analysis (for dysarthria) to generate a binary "possible stroke" output.[18] For example, the FAST-ED application provides structured guidance to paramedics with limited stroke-specific training, potentially enhancing triage accuracy.[19] Similarly, the eFACE tool has demonstrated excellent inter-rater reliability (ICC 0.96) when applied to standardized frontal photographs, supporting the feasibility of AI-driven facial symmetry analysis in the field.[20]

Inside the ambulance, AI has been applied to transform standard EMS documentation into diagnostic data. Mayampurath et al. demonstrated that Natural Language Processing (NLP) applied to paramedic run-report narratives could identify LVO and Comprehensive Stroke Center (CSC)–eligible cases with superior discrimination compared to the Cincinnati Prehospital Stroke Scale (CPSS) alone (c-statistic 0.73 vs. 0.67).[21] Complementing text analysis, machine learning models using vital signs and hemodynamic signals have also shown promise. Saban et al. utilized XGBoost and Random Forest models across 8,221 encounters, outperforming CPSS in sensitivity and identifying strokes missed by standard protocols.[22]

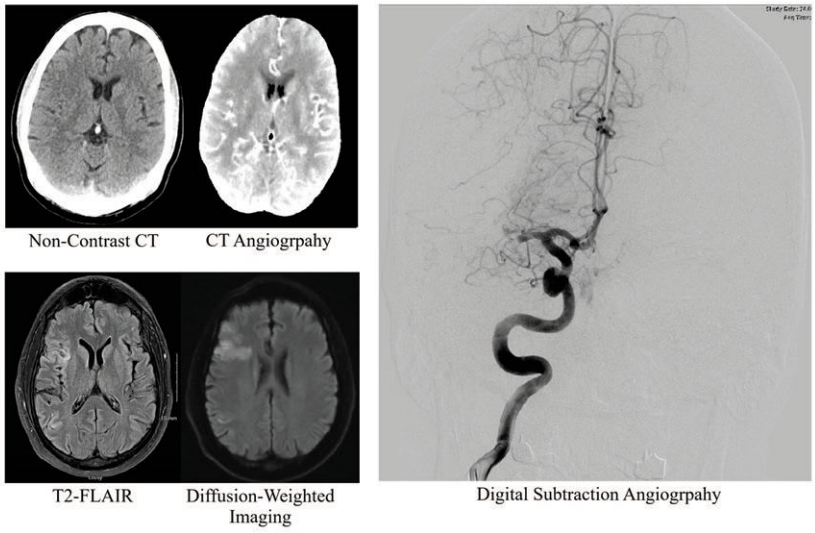



Figure 2. Imaging modalities in ischemic stroke.
*DSA image of complete MCA occlusion reproduced from Klapp Oliger et al. (2020), https://doi.org/10.1007/s42399-020-00641-1, licensed under CC BY 4.0 (http://creativecommons.org/licenses/by/4.0/); no changes.*

## Network Coordination and Inter-Facility Triage

Automated software for vessel occlusion detection has become an important component of acute stroke triage, offering a HIPAA-compliant platform for coordinated communication between EMS and hospital teams.[23] In a study across 166 centers, AI use shortened the median neurointerventional notification time by 39 minutes.[23] The benefit appears most pronounced in resource-limited primary stroke centers lacking 24-hour neuroradiology coverage, where AI deployment reduced presentation-to-transfer times by approximately 50% (median reduction 106 minutes).[23] By streamlining the "handshake" between prehospital providers and stroke teams, these tools reduce door-to-arteriotomy times and prevent the loss of thrombectomy eligibility during transfer.[23]

However, it should be noted that nearly all stroke-focused prehospital models to date have been developed and tested retrospectively within single EMS systems, often using local documentation practices. Prospective studies demonstrate that AI-guided transport actually shortens onset-to-reperfusion times or yields better functional outcomes are still lacking. As these tools move toward deployment, careful attention will be required to define acceptable over- versus under-triage thresholds and ensure that model behavior is interpretable by prehospital providers.

## AI in Acute Diagnostic Imaging (Figure 2)

### *Intracranial Hemorrhage Detection*

One of the largest areas of application for AI tools in neuroendovascular disease and management is in enhanced detection of intracranial hemorrhage (ICH). Developing deep learning and convolutional neural network (CNN) based AI systems in this arena show promising potential in accelerating the workflow and assisting clinicians in expedient diagnosis and decision-making by quickly detecting and classifying subtypes of ICH from head CT scans. A deep learning algorithm trained using the 2019-RSNA Brain CT Hemorrhage Challenge dataset comprised of over 25,000 CT scans pre-annotated for ICH subtypes could accurately classify acute ICH and its five subtypes with areas under the curve (AUCs) of 0.988 (ICH), 0.984 (EDH), 0.992 (IPH), 0.996 (IVH), 0.985 (SAH), and 0.983 (SDH), a level of accuracy almost comparable to expert radiologists.[24] Additionally, classification of ICH on two independent external datasets (PhysioNet-ICH, AUC: 0.964, 95% CI: [0.9549, 0.9731]; CQ500, AUC: 0.949, 95% CI: [0.9480, 0.9507]) showed sustained high performance, demonstrating generalization beyond the original dataset.[24] AI-based systems such as this could serve as assistive tools in routine clinical ICH diagnosis, potentially reducing missed cases and workload for radiologists and stroke care providers.

### *Automated ASPECTS*

The standardized 10-point ASPECTS scoring tool has been widely used to evaluate the severity of acute ischemic stroke of the anterior circulation based on NCCT findings. However, its suffers from significant interobserver variability, with experts demonstrating a reliability coefficient (ICC) of only 0.62,[25] leading to inconsistent decisions in "borderline" cases regarding EVT eligibility. Automatization of this system with AI could provide more consistent, instantaneous scoring

in places where clinicians may show variability in detecting the early subtle changes of a stroke event, such as loss of normal gray/white matter differentiation and cortical effacement. Several platforms are emerging to address this unmet need, such as e-ASPECTS, which has been demonstrated to be statistically noninferior to neuroradiologists and stroke physicians.[26,27] Utilization of these technologies may eventually serve as excellent adjuncts to expert evaluations of CT imaging of acute stroke patients.

### *Large Vessel Occlusion Detection*

Several FDA-approved AI software programs for radiological detection of LVO emerging in recent years, including Viz LVO, CINA LVO, Rapid LVO, and others, support the benefits of AI-augmentation in the rapid diagnosis and treatment of acute LVO strokes.[28] Many of these softwares utilize systems that automatically flag suspected LVOs and immediately notify providers to facilitate faster response times.

A meta-analysis examined 38 studies published between 2019 and 2023 comparing AI-augmented LVO detection to non-AI in various time measurements following the patient's progression from last known well to endovascular intervention in acute ischemic strokes.[29] They found that AI-augmented methods demonstrated higher stroke detection sensitivity compared to non-AI methods. Additionally, there were several statistically significant differences of metrics in favor of AI-augmentation, including Triage Time (odds ratio (OR): 0.39, 95% CI: [0.29, 0.54], $p < 0.001$), Door-to-Intervention Notification Time (OR: 0.30, 95% CI: [0.21, 0.42], $p < 0.001$), and Door-to-Arterial Puncture Time (OR: 0.50, 95% CI: [0.30, 0.82], $p = 0.007$).29 These findings suggest that AI-augmentation may have beneficial impacts in the efficiency of stroke detection and management, which may contribute to improved stroke team responsiveness, more rapid diagnosis, more patients receiving interventions within the optimal treatment window, and ultimately reduced adverse clinical outcomes of acute ischemic stroke.

### *Perfusion Imaging and Tissue Salvageability*

AI-based systems are also being explored in CT and MRI perfusion imaging to aid in differentiating the ischemic core from the penumbra and surrounding normal tissue. One study compared a deep learning AI system to the traditional CT perfusion software utilizing relative contralateral hemisphere thresholding,[30] concluding that deep learning algorithms (DC: 0.64 +/- 0.03) could outperform traditionally used software (DC: 0.31 +/- 0.17) in segmentation of infarcted tissue. Additionally, a multicenter retrospective study of 299 patients performed similar comparisons for MRI perfusion imaging between the deep learning algorithm JLK-PWI and the established RAPID software.[31] This study found concordance between JLD-PWI and RAPID estimations of ischemic core (concordance correlation coefficient (CCC) = 0.87; $p < 0.001$) and hypoperfused (CCC = 0.88; $p < 0.001$) volumes. They also demonstrated high concordance in endovascular therapy (EVT) eligibility classification based on DAWN (Cohen's $\kappa \approx 0.80 – 0.900$) and DEFUSE-3 ($\kappa \approx 0.76$) criteria. Deep learning models show promising use in other areas such as prediction of final infarct volume based on initial imaging parameters, which may even further guide and support clinical decision making.[32]

### *Collateral Assessment and Emerging Techniques*

A key determining factors of clinical outcomes in patients with AIS is collateral circulation, as tissue with adequate collateral circulation in the ischemic penumbra can potentially be salvageable from permanent damage as opposed to non-collateralized tissue in the ischemic core. Consequently, tools that can accurately evaluate collateral status are becoming increasingly important for guiding expectations of outcomes in endovascular treatment options for acute ischemic stroke.

While digital subtraction angiography has been the gold standard for evaluation of ischemic occlusions and collateral supply, it is limited by being both invasive and time intensive.[33] Alternative methods, including single-phase and multi-phase CT angiography (sCTA and mCTA), are currently being investigated as CTA is widely accessible, non-invasive, and safe to perform. sCTA relies on capturing a single image phase, typically the peak arterial phase, whereas mCTA captures arterial, venous, and delayed venous phases.[34] A study comparing the two found that mCTA offered higher sensitivity in detection of isolated intracranial ICA occlusions (79.31%, [62.84%-95.78%]) compared to sCTA (48.28%, [28.36%-68.19%]).[34] This suggests that mCTA may be a more accurate method for detailed evaluation of collaterals and selection of

patients who may benefit from reperfusion therapies.

Developments are also emerging in MRI diffusion weighted imaging (DWI) infarct segmentation and optical cerebral blood flow monitoring. While more time-intensive than CT imaging, MRI often provides more information useful for the evaluation of ischemic stroke, including infarct core evaluation, hemorrhagic transformation, and evidence of prior infarcts,[35] but can be limited by its time-consuming nature compared to CT. This is especially relevant when considering that accurate infarct volume measurements using DWI require manual segmentation of the borders of a stroke, which increases the variability and time needed to have consistent stroke evaluations.

Deep-learning programs are being studied to alleviate some of this burden and to provide faster and more consistent interpretations of DWI. One study compared a DWI infarct segmentation program based on deep learning (JBS-01K) to one based on apparent diffusion coefficient (ADC) thresholds (RAPID DWI) in 414 patients.[36] It concluded that infarct volumes measured by JBS-01K were more accurate and consistent to manually segmented infarct volumes than those measured by RAPID DWI (overall accuracy 98.1% vs. 94.0%; $p = 0.002$).[36] Additionally, RAPID DWI more frequently underestimated or failed to detect small ischemic lesions compared to JBS-01K.[36] As deep-learning models continue to improve, clinicians can deepen understanding of the pathophysiological mechanisms of stroke to provide more optimal therapies to patients.

## AI-Supported Patient Selection and Risk Stratification for Reperfusion Therapies

### *IV Thrombolysis Selection*

AI in IV thrombolysis (IVT) is most useful as an imaging "safety net": rapid exclusion of contraindicating hemorrhage on non-contrast CT, support for subtle early ischemic change, and more reproducible infarct-extent estimation (e.g., automated ASPECTS). Deep-learning ICH detectors generally show high diagnostic performance in aggregate, supporting their role as second readers that can reduce missed hemorrhage in time-pressured settings.[37]

For early ischemia on non-contrast CT, the appropriate clinical posture is decision support, not automation: performance varies across scanners and sites, and models should be deployed assuming domain shift with ongoing monitoring.[38] Automated tools such as ASPECTS may improve standardization of infarct-extent estimation and reduce variability in scoring, but still should be integrated as decision support rather than a sole gatekeeper.[39]

A second IVT use case is late-window/unknown-onset thrombolysis, where imaging selection is required and algorithmic perfusion quantification is already embedded in contemporary care. Patient-level evidence supports alteplase for selected 4.5–9 hour/wake-up presentations in select patients, with improved excellent functional outcomes but higher symptomatic ICH risk.[40] Newer deep-learning CTP approaches aim to move beyond threshold maps toward individualized tissue-fate prediction, but require careful validation before influencing "treat vs. no treat" decisions.[41]

### *Endovascular Thrombectomy Selection*

For thrombectomy, CTA LVO AI functions as a triage aid in multihospital stroke networks; performance is strongest for proximal occlusions, and false-positive burden varies by platform, reinforcing the need for governance to avoid alert fatigue.[41,42]

Automated infarct-burden estimates may reduce variability that influences EVT eligibility and downstream decisions.[39] In late windows, modeling is evolving from static "core size" thresholds toward voxelwise probabilistic tissue-fate prediction, suggesting that selection may increasingly rely on individualized estimates of tissue likely to be saved, though this remains a forward-looking claim.[41] Finally, it is worth stating explicitly that perfusion-based imaging selection is embedded in guideline-driven late-window EVT paradigms, even if not branded AI.[43]

### *Complication and Outcome Prediction*

A pragmatic role for AI is risk stratification used to tailor monitoring and resources rather than replace reperfusion decisions. Across meta-analytic evidence, models can predict hemorrhagic transformation (HT) with reasonable overall discrimination, but quality, calibration, and external validation remain variable.[44,45] In practice, the most operationally useful targets are those that change care pathways (e.g., early HT risk to guide monitoring intensity, malignant edema risk to trigger ICU planning and neurosurgical readiness), but these models still require robust external validation and site-level calibration before deployment.[44-46]

Outcome prediction models are best used to inform counseling and post-acute planning rather than as standalone "go/no-go" selection tools. Traditional clinical scores remain valuable because they are interpretable and have demonstrated robust prognostic performance across ischemic stroke care settings, including patients treated with IV thrombolysis and those receiving no acute therapy.[47]

## Workflow Optimization and Systems of Care

### *Reducing Time to Treatment*

AI's most consistent benefit in acute stroke systems is workflow acceleration, enabling faster imaging-based detection (including large vessel occlusion) and earlier downstream mobilization of treatment teams.[48,49] In a Viz.ai meta-analysis, implementation was associated with significant reductions in multiple process times while 90 day clinical outcomes were not significantly different, reinforcing that the most reproducible gains are in process metrics, with outcome effects more context dependent.[48,49]

### *Communication Platforms as Interventions*

Operationally, modern stroke AI is often an ecosystem (worklist triage, secure team notification, and automated alerts) rather than a stand-alone algorithm.[50] "Flag-and-notify" workflows can speed mobilization by delivering rapid, automated team alerts, but their clinical value depends on real-world diagnostic performance (e.g., sensitivity and accuracy) when deployed in practice.[51] Vendor-specific evidence (e.g., CTA LVO triage platforms) broadly supports faster notification and transfer metrics, with treatment time gains varying by local constraints.[52,53]

### *Synergy with Telestroke Platforms*

AI can act as a force multiplier for telestroke by triaging imaging and accelerating remote specialist engagement, supporting virtual stroke networks across distributed hospitals.[54,55] The systems level hypothesis is compelling, but networks should evaluate not only time metrics but also equity, durability, and whether increases in EVT utilization reflect improved selection rather than over-triage.[56]

## Challenges, Limitations, and Ethical Considerations

AI in acute stroke is a high-stakes, time-critical use case: modest performance degradation or false-positive burden can translate into workflow harm, wasted transfers, or inequitable care.

### *Generalizability and Equity*

Domain shift remains the central threat: models trained on selected academic datasets may underperform across scanners, protocols, prevalence, and patient populations.[48] In low-prevalence real-world cohorts, PPV can be poor and false positives occur.[57] Bias in medical imaging AI is common (including documented differences related to sex, race, and geography), and limited reporting of patient characteristics in many studies can hinder detection and mitigation of these biases.[48] Standardized reporting and robust real-world validation are increasingly emphasized for stroke imaging AI.[58]

### *Trust, Explainability, and Workflow Safety*

Many deep-learning systems are partially opaque, complicating trust and governance when errors occur. Explainable approaches can improve transparency, but do not eliminate black-box risk and should not be treated as definitive explanations for model decisions.[48] Imperfect performance can blunt impact; benefits depend on real-world integration (how alerts are delivered) as well as on model accuracy.[51]

### *Regulations and Accountability*

Stroke imaging AI is often regulated as software as a medical device and framed as triage/decision support rather than autonomous diagnosis, so clearance often emphasizes diagnostic performance and workflow endpoints rather than outcome trials.[50] Liability generally remains with clinicians and institutions, which makes local policies for documentation and oversight especially important when AI outputs are used or overridden.[59]

## Future Directions and Conclusion

The next phase of stroke imaging AI should move beyond narrow, single-feature tools and retrospective accuracy reports toward evidence that these systems improve care when used in real clinical workflows. Wardlaw and colleagues emphasize that diagnostic AI can influence treatment decisions, for benefit or harm, yet has often not been evaluated to the rigorous standards expected for therapeutics. They argue that the priority should be prospective, real-world, multicenter evaluations that test whether AI changes management, integrates safely into practice, and improves patient and

system relevant outcomes instead of just diagnostic performance.[48]

Overall, AI in acute ischemic stroke is best viewed as augmentation. Today, the most consistent evidence supports workflow acceleration and standardization; tomorrow, progress should be judged by prospective effectiveness, safe integration, and equitable benefit across populations and care settings.

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## Disclosure

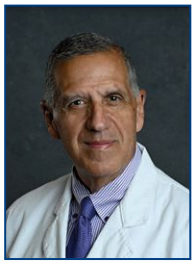
No financial disclosures reported. Generative AI (Gemini Nano Banana 3.0) was used to draft Figure 1. **MM**

# Current Concepts in the Management of Cerebral Aneurysms

*by Camilo R. Gomez, MD, Balint Otvos, MD, PhD, Kimberley Pfeiffer, FNP, Farhan Siddiq, MD, Michael R. Chicoine, MD & Adnan I. Qureshi, MD*

Health Care

**The management of cerebral aneurysms demands both technical excellence and disciplined clinical judgment.**



Camilo R. Gomez, MD, MBA, (pictured), Balint Otvos, MD, PhD, Kimberley Pfeiffer, FNP, Farhan Siddiq, MD, **Michael R. Chicoine, MD**, and Adnan I. Qureshi, MD, are with the Comprehensive Stroke Center, and the Departments of Neurology and Neurosurgery, University of Missouri School of Medicine, Columbia, Missouri, USA.

## Abstract

**Cerebral aneurysms represent a heterogeneous group of vascular lesions whose clinical behavior ranges from incidental, asymptomatic findings to catastrophic aneurysmal subarachnoid hemorrhage. Despite major advances in neuroimaging, microsurgical technique, and endovascular technology, the management of both ruptured and unruptured cerebral aneurysms remains complex and highly individualized. This review examines current concepts in aneurysm pathobiology, natural history, risk stratification, and contemporary treatment strategies, emphasizing durable clinical principles that transcend evolving technology. Particular attention is given to the balance between conservative surveillance and intervention in unruptured aneurysms, as well as the time-critical priorities, complications, and neurocritical care considerations in ruptured aneurysms. The relative roles of microsurgical and endovascular therapies are discussed through the lens of long-term durability, retreatment risk, and patient-specific anatomy. Ultimately, optimal outcomes depend less on any single technique than on disciplined clinical judgment, longitudinal thinking, and true interdisciplinary collaboration within experienced neurovascular centers.**

## Keywords

Cerebral aneurysm, subarachnoid hemorrhage, aneurysm pathobiology.

## Introduction

Cerebral aneurysms remain among the most consequential vascular lesions encountered in vascular neurology and neurosurgery. Their natural history spans a wide spectrum, from incidental, clinically silent findings to catastrophic aneurysmal subarachnoid hemorrhage with high rates of mortality and long-term disability.[1-3] Despite major advances in imaging, microsurgical technique, and endovascular technology over the past three decades, decision-making in aneurysm management remains nuanced, individualized, and at times controversial.[1, 2, 4-8]

The modern clinician must integrate epidemiologic data, patient-specific risk factors, aneurysm morphology, hemodynamic considerations, and the relative strengths and

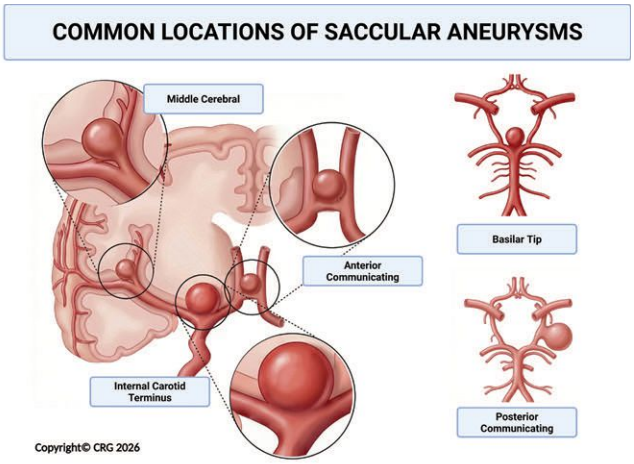



Figure 1. Common locations of saccular aneurysms.

limitations of available treatment modalities. This review summarizes current concepts in the evaluation and management of both unruptured and ruptured cerebral aneurysms, emphasizing principles that remain durable despite evolving technology.

## Epidemiology and Pathobiology

Intracranial aneurysms are present in approximately three to five percent of the general population.[1, 2] Most remain asymptomatic throughout life, yet rupture carries devastating consequences. The annual incidence of aneurysmal subarachnoid hemorrhage is approximately six to 10 per 100,000 persons, with case fatality rates approaching 30 percent and significant long-term neurologic morbidity in many survivors.[1, 2]

Aneurysm formation is multifactorial.[9] Structural weakness at arterial bifurcations, chronic hemodynamic stress, inflammatory changes within the vessel wall, and genetic predisposition all contribute. Established risk factors include cigarette smoking, hypertension, female sex, and advancing age. Certain heritable conditions, including autosomal dominant polycystic kidney disease and connective tissue disorders, further increase risk.[8, 9]

Importantly, aneurysm biology is dynamic. Growth, wall remodeling, and inflammatory activity evolve over time, challenging the assumption that a single snapshot adequately defines future behavior.[1, 2, 9]

## Classification and Anatomic Considerations

Cerebral aneurysms are commonly classified by size, geometry, and location. Historically, there has been considerable variability in the categorization of aneurysms by size.[1-4, 10] A recent focused review that calls for standardization proposes the following subgroups: small (<5 mm), medium (5-10 mm), large (10-25 mm), and giant (>25 mm).[11] In our view, this approach, which integrates elements of the International Study of Unruptured Intracranial Aneurysms (ISUIA)[3, 8] and the Japanese Unruptured Cerebral Aneurysm Study (UCAS),[2] appears reasonable and practical, with clinical utility. In any case, a review of the literature must consider the variability of published schemes.

In terms of their morphology (geometry), aneurysms can be classified as saccular (i.e., "berry"), fusiform (e.g., dolichoectatic), or dissecting (e.g., mycotic), each with distinct therapeutic implications. For the purposes of this review, we will focus our discussion primarily on saccular aneurysms, arguably the most prevalent and clinically important in the practice of vascular neurology and neurosurgery. A second aspect of aneurysm morphology is the dome-to-neck ratio (DNR), which addresses "wide-necked" aneurysms (i.e., those with DNR <2), whose endovascular treatment must account for this attribute when planning the choice and approach of interventional procedure.[11]

Finally, location remains a critical determinant of both rupture risk and treatment strategy (Figure 1). Carotid circulation aneurysms, particularly those of the anterior communicating artery and middle cerebral artery bifurcation, account for the majority of ruptured lesions.[12, 13] Vertebrobasilar circulation aneurysms, though less common, exhibit a disproportionately higher rupture risk at smaller sizes and often pose greater technical therapeutic challenges.[12, 13]

## Unruptured Cerebral Aneurysms

### *Natural History and Risk Stratification*

The management of unruptured aneurysms requires careful balancing of rupture risk against treatment-related morbidity.[1-4, 6, 8] Large observational studies have demonstrated that rupture risk increases with aneurysm size, location in the vertebrobasilar circulation, irregular morphology, and documented growth. Patient-specific factors, including age, smoking status, hypertension, and prior subarachnoid hemorrhage, further modulate risk.[1-4, 6, 8]

Although we generally avoid rigid intellectual anchors and oversimplified scores, risk prediction

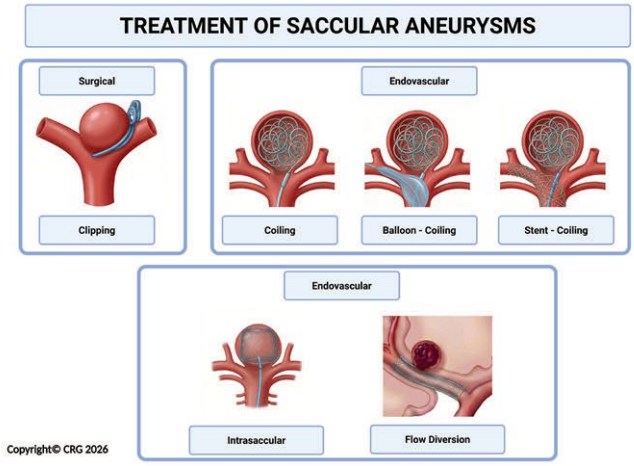



Figure 2. Different treatment options and techniques for treating saccular aneurysms. The common denominator of all these approaches is excluding the aneurysm from the circulation, preventing blood from entering the aneurysm sac, and thereby preventing its rupture.

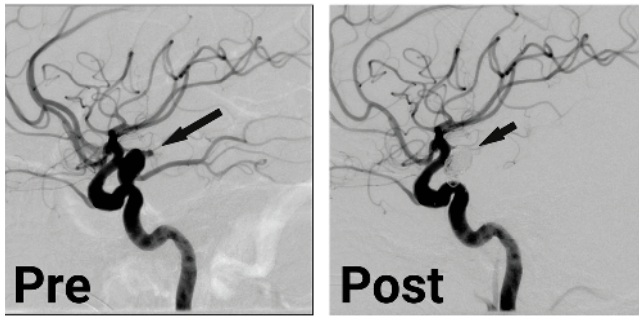



Figure 3. Large saccular pleomorphic aneurysm of the communicating segment of the internal carotid artery, successfully treated by primary coil embolization.

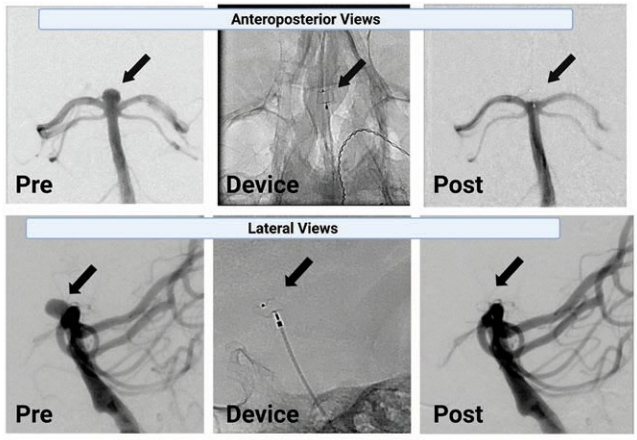



Figure 4. Medium-sized ovoid aneurysm of the basilar artery tip successfully treated endovascularly using an intrasaccular device [i.e., Woven-Endo Bridge (WEB®)].

models such as PHASES provide a population-level perspective that can serve as a backdrop for our clinical judgment without ever replacing it.[14] In this context, among the various attributes of identified cerebral aneurysms, longitudinal imaging demonstrating aneurysm growth remains one of the most compelling indicators for intervention.

### *Surveillance Versus Intervention*

For many small, asymptomatic aneurysms in low-risk patients, conservative management with serial imaging is appropriate.[3, 4, 6, 14] This approach requires patient education, risk factor modification, and adherence to follow-up protocols.

Intervention is generally favored for aneurysms that demonstrate growth, irregular morphology, symptomatic presentation, or a high-risk location. Younger patients with longer life expectancy warrant a lower treatment threshold, given the cumulative risk of rupture over time.[3, 4, 6, 14]

### *Treatment Options for Unruptured Aneurysms*

Microsurgical clipping remains a definitive therapy, offering durable aneurysm exclusion with low recurrence rates (Figure 2).[15] It is particularly well-suited to treating middle cerebral artery aneurysms and aneurysms with branch incorporation.[7, 15]

Endovascular approaches have expanded considerably and now include coil embolization (either primary or balloon- or stent-assisted for the management of wide-necked aneurysms), flow diversion, and intrasaccular devices (Figures 2, 3, and 4). [5] Flow-diversion devices have transformed the management of complex, wide-necked, and fusiform aneurysms, though they require prolonged dual antiplatelet therapy to prevent thrombosis and long-term imaging surveillance (Figure 2).[5]

No single modality is universally superior. Optimal outcomes depend on matching aneurysm morphology and patient factors to the most appropriate technique within an experienced, multidisciplinary environment.

## Ruptured Cerebral Aneurysms

### *Clinical Presentation and Initial Evaluation*

Aneurysmal rupture typically presents with sudden, severe headache, often described as having a

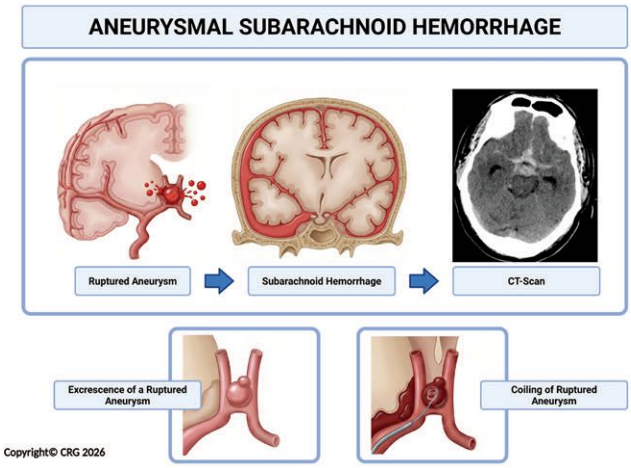



Figure 5. Aneurysmal subarachnoid hemorrhage. Aneurysms rupture, typically showing an excrescence that signals the vulnerability for rupture and re-rupture, and cause widespread bleeding throughout the subarachnoid space. This is readily detected, in most cases, by CT scanning. Presently, the preferred therapeutic approach to securing a ruptured aneurysm is endovascular therapy.

"thunderclap" onset, accompanied by nausea, vomiting, meningismus, and varying degrees of impaired consciousness (Figure 5).[16] Early misdiagnosis remains a persistent problem, particularly when symptoms are attributed to migraine or other benign etiologies.

Non-contrast head computed tomography (CT) remains the cornerstone of initial diagnosis, with near-complete sensitivity within the first six hours.[16] CT angiography (CTA) rapidly identifies the ruptured aneurysm in most cases, guiding urgent treatment decisions. In patients whose initial CT is negative or equivocal, and the clinical picture is sufficiently worrisome, additional diagnostic investigations are invariably warranted. Historically, we have relied on spinal fluid examination as the next step in care. Demonstrating xanthochromia due to hemoglobin degradation products in the subarachnoid space is a highly specific diagnostic finding.[16] However, at present, magnetic resonance imaging (MRI), including susceptibility-weighted imaging (SWI) sequences, can also be used to diagnose subarachnoid hemorrhage with a sensitivity of approximately 90-95%.[17, 18]

## Grading and Prognosis

Clinical grading systems, including the Hunt and Hess and the World Federation of Neurological Surgeons scales, correlate with outcomes and inform perioperative risk.[16] Imaging grading of subarachnoid blood burden remains predictive of delayed cerebral ischemia and vasospasm risk.

## Definitive Treatment of Ruptured Aneurysms

The primary objective in ruptured aneurysm management is prompt and durable exclusion of the aneurysm from the circulation to prevent rebleeding (Figures 2, 3, 4, and 5).

- ***Surgical Clipping***

Microsurgical clipping provides immediate obliteration of the aneurysm (Figure 2) and remains particularly advantageous for aneurysms associated with large intracerebral hematomas that, in and of themselves, require evacuation, and those with branch incorporation.[6, 12, 15] Long-term durability is excellent, with very low retreatment rates. [15]

- ***Endovascular Therapy***

Endovascular therapy has become the preferred treatment for many ruptured aneurysms (Figure 5), especially those of the vertebrobasilar circulation (Figures 2 and 4).[12, 13, 15] Randomized trials have demonstrated improved early functional outcomes in selected patients, though slightly higher rates of aneurysm recurrence and retreatment demand post-treatment surveillance.[12, 13, 15] An additional consideration for this approach is that adjunctive devices (e.g., stents, flow diverters), often required to treat aneurysms with complex anatomy (Figure 2), also necessitate antiplatelet therapy to prevent thrombosis. In the short term, this is typically applied after a primarily hemorrhagic process, creating predictable difficulties during the neurocritical care interval.[5]

## Comparative Considerations

Large trials and meta-analyses demonstrate that outcomes depend more on appropriate patient selection and institutional expertise than on modality alone. Multidisciplinary decision-making remains essential.[10, 12, 13, 15]

## Neurocritical Care and Complications

Perioperatively, patients with ruptured aneurysms require meticulous neurocritical care. Delayed cerebral ischemia, vasospasm, hydrocephalus, electrolyte disturbances, and cardiopulmonary complications are common.[6, 10, 19]

Enteral nimodipine remains generally accepted to improve outcomes after aneurysmal subarachnoid

hemorrhage, and is typically started upon admission. For patients becoming symptomatic or those whose cerebral hemodynamic monitoring trends to worsening spasm, intravascular volume optimization, induced hypertension, and inotropic support for cardiac output are practical and widely accepted strategies for management in the neurocritical unit.[6, 10]

As time elapses, if these measures fail to improve the patient's clinical status, endovascular treatment becomes the next therapeutic option.[20] This modality includes intra-arterial instillation of vasodilators (e.g., calcium channel blockers) and angioplasty with balloons or other devices (e.g., Comaneci®, p-Relax®).

Presently, our understanding of the effects of subarachnoid hemorrhage on the cerebral circulation is that it represents an exceedingly more complex process, including cortical spreading depolarizations and cerebral metabolic crises, all converging to induce secondary (i.e., delayed) cerebral ischemic injury.[19] Indeed, the current concept of what we have historically called "vasospasm" includes a tangible yet difficult-to-address microcirculatory component, one that will necessitate a broader therapeutic approach.[19]

### *Long-Term Outcomes and Follow-Up*

Survivors of aneurysmal subarachnoid hemorrhage often face persistent cognitive, emotional, and functional deficits despite good motor recovery. Long-term follow-up should address neuropsychological health, quality of life, and surveillance imaging for *de novo* or recurrent aneurysms.[15]

## Conclusion

The management of cerebral aneurysms demands both technical excellence and disciplined clinical judgment. Advances in imaging and intervention have expanded therapeutic options, yet they have also increased complexity. Durable principles remain unchanged: careful patient selection, respect for aneurysm biology, and interdisciplinary collaboration. When applied consistently, these principles offer the best opportunity to reduce the devastating impact of aneurysmal disease.

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## Disclosure

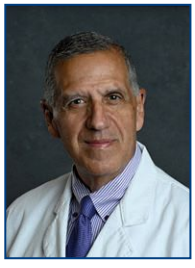
No financial disclosures reported. Grammarly was used for editing. Figures 1, 2, and 5 are copyrighted by CRG. **MM**

# Long-Term Cardiac Rhythm Monitoring After Ischemic Stroke: Detecting Atrial Fibrillation in the Era of Atrial Cardiopathy

*by Kimberley Pfeiffer, FNP, Alibay Jafarli, MD, Francisco E. Gomez, MD, Brandi R. French, MD, Adnan I. Qureshi, MD & Camilo R. Gomez, MD*

Health Care

**Atrial fiberillation should be viewed not as an isolated rhythm abnormality, but as a marker of atrial cardiopathy.**



Kimberley Pfeiffer, FNP, Alibay Jafarli, MD, Francisco E. Gomez, MD, Brandi R. French, MD, Adnan I. Qureshi, MD & Camilo R. Gomez, MD, MBA, (pictured), are with the Comprehensive Stroke Center, and the Departments of Neurology and Neurosurgery, University of Missouri School of Medicine, Columbia, Missouri, USA.

## Abstract

**Long-term cardiac rhythm monitoring has become a central component of the diagnostic evaluation of patients with ischemic stroke in whom atrial fibrillation (AF) is suspected but not initially detected. Implantable loop recorders (ILRs) substantially increase AF detection compared with conventional short-term monitoring, particularly when surveillance is extended over months to years. However, increased detection has not consistently translated into fewer strokes, underscoring important limitations in current paradigms. Growing evidence supports atrial cardiopathy as the underlying substrate predisposing to thromboembolism, with AF representing a variable electrical manifestation rather than the primary disease itself. Electrocardiographic and echocardiographic markers of atrial cardiopathy, including abnormal P-wave indices, left atrial enlargement, and impaired atrial function, help identify patients most likely to benefit from prolonged monitoring. This review examines the role of ILRs in post-stroke patients through the lens of atrial cardiopathy, emphasizing biologic plausibility, patient selection, and disciplined interpretation of monitoring results to optimize clinical relevance and avoid uncritical escalation of therapy.**

## Key Words

Atrial fibrillation, implantable loop recorders, atrial cardiopathy.

## Introduction

Atrial fibrillation (AF) remains one of the most powerful and modifiable risk factors for ischemic stroke. Yet, in a substantial proportion of patients presenting with ischemic stroke, AF is not documented during the index hospitalization or, in the immediate follow-up interval, with conventional short-term monitoring.[1,2] This diagnostic gap has led to an expanding role for prolonged cardiac rhythm monitoring, particularly through implantable loop recorders (ILRs).[1,2]

Over the past decade, our conceptual framework has evolved. We increasingly recognize that AF is often not the primary disease, but rather the electrical manifestation of an underlying atrial myopathy.[3-8] This construct, broadly referred to as "atrial cardiopathy"

or "atrial cardiomyopathy," reframes the discussion away from binary detection of AF toward a more nuanced assessment of atrial structural, functional, electrical, and biochemical abnormalities that predispose to thromboembolism (Figure 1).[1-8]

Within this paradigm, ILRs serve not merely as a detection tool but as a longitudinal probe into atrial disease biology. Their greatest value may lie in appropriately selected patients, particularly those with clinical, electrocardiographic, and echocardiographic markers of atrial cardiopathy, in whom the likelihood of meaningful arrhythmia detection is highest.

## Limitations of Conventional Rhythm Monitoring

Standard inpatient telemetry and short-duration Holter monitoring remain insensitive for detecting paroxysmal AF.[9-12] Numerous studies have demonstrated that monitoring limited to 24 to 72 hours identifies only a minority of cases that ultimately have AF on prolonged follow-up.[9-12] This limitation is not merely technical, but biological. Paroxysmal AF may be infrequent, asymptomatic, and temporally distant from the index cerebrovascular event.

Moreover, the concept of "absence of evidence" has often been misinterpreted as "evidence of absence," leading to premature closure of diagnostic evaluation. This has been particularly problematic in patients labeled as having a "stroke of unknown etiology," in whom cardiogenic embolism remains biologically plausible despite the lack of documented arrhythmia.

## Implantable Loop Recorders: Technical Considerations and Capabilities

Modern ILRs are subcutaneous devices that can provide continuous rhythm monitoring for several years. They automatically detect AF based on rhythm irregularity and R-R variability, with remote transmission enabling longitudinal data capture without patient participation (Figure 2).[13]

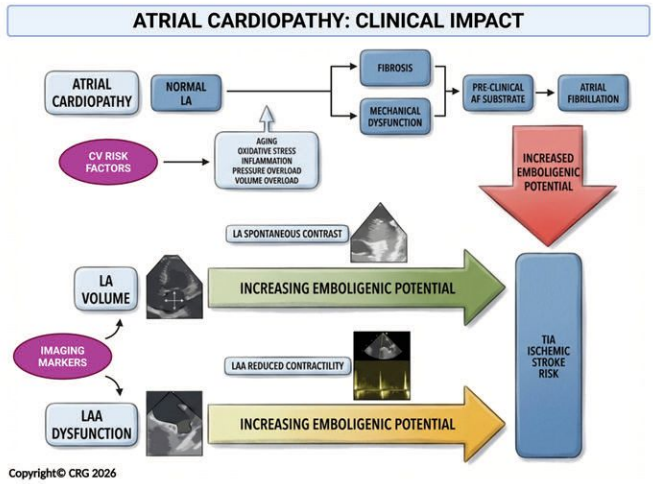



Figure 1
Atrial cardiopathy and the dimensions of its clinical impact. Over the course of time, normal atria are affected by various cardiovascular risk factors, contributing to the development of fibrosis and mechanical dysfunction.. In turn, these changes affect normal electrical conduction, often leading to atrial fibrillation. Even in cases when atrial fibrillation has not been identified, imaging markers of atrial dysfunction and enlargement contribute to the prediction of its eventual identification.
LA =Left atrium – LAA = Left atrial appendage

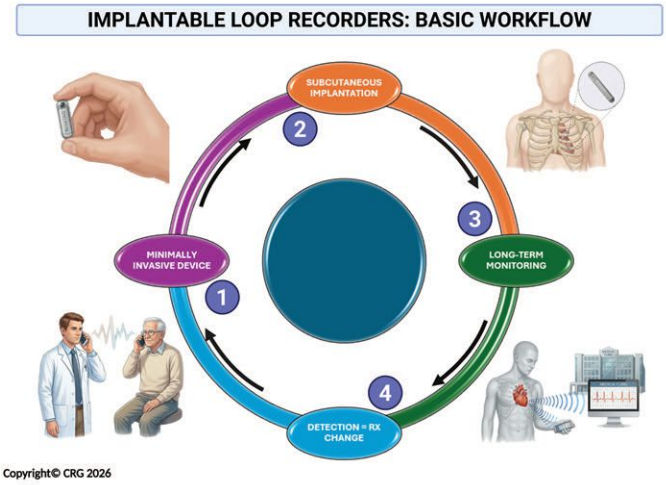



Figure 2
Implantable loop recorders are very small devices that are essentially "injected" (i.e., minimally invasive procedure) under the skin of the anterior thoracic wall under local anesthesia, and that record continuously, transmitting heart rhythm changes over the cloud to allow interpretation. Once atrial fibrillation is detected, the physician can notify the patient and additional or alternative management measures can be implemented.
RX = Management

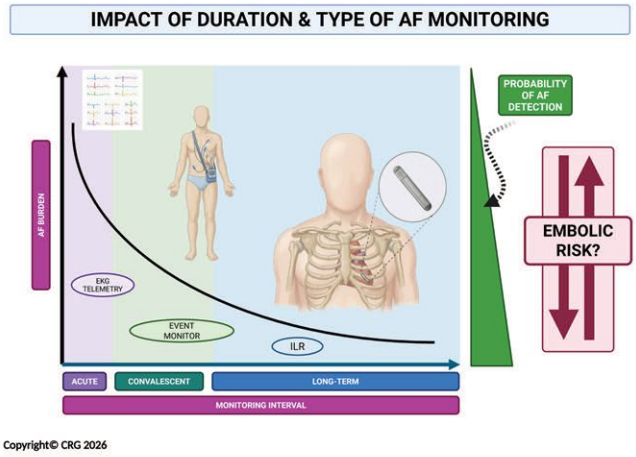



Figure 3
Differences in the application of the various types of monitoring techniques, as they are utilized across the stroke care continuum, for atrial fibrillation detection. Despite the higher burden during the acute phase, very short paroxysmal episodes can be missed. As time elapses, however, even shorter episodes (i.e., "lower burden") can be more reliably detected by implantable loop recorders. Whether, in fact, earlier or later episodes of AF have a greater or lower embolic significance remains debatable.
AF = Atrial fibrillation; ILR = Implantable loop recorders; EKG = Electrocardiogram

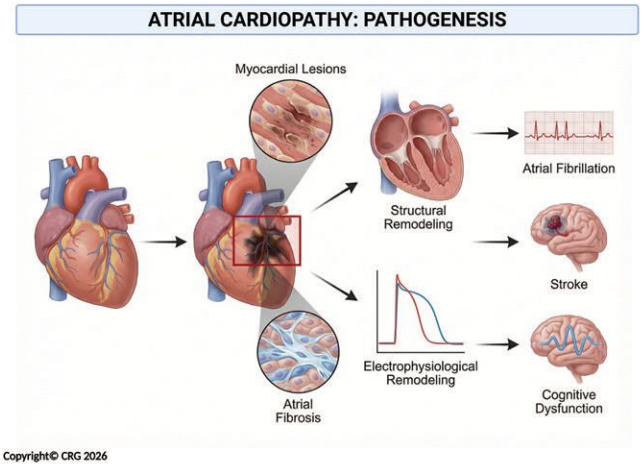



Figure 4
The pathogenic relationship between atrial cardiopathy and atrial fibrillation is displayed in the figure. Fibrosis and prior injuries of the myocardium lead to structural remodeling, atrial strain, and these in turn translate into atrial fibrillation with increased risk for stroke and cognitive dysfunction.

Compared with external monitors, ILRs offer three critical advantages. First, they eliminate compliance limitations. Second, they provide true long-term surveillance rather than episodic sampling. Third, they allow temporal correlation between arrhythmia burden and clinical events, enabling a more sophisticated interpretation of AF phenotypes. These attributes are particularly relevant in post-stroke populations, where AF episodes may be infrequent, delayed, or clinically silent.[13]

## Detection Yield of Implantable loop Recorders After Stroke

Multiple randomized trials, observational studies, and meta-analyses have demonstrated that ILRs substantially increase AF detection compared with conventional monitoring (Figure 3).[9-13] Detection rates increase progressively with monitoring duration, reaching approximately 12 to 15 percent at one year and exceeding 25 percent with extended follow-up in selected populations.[9-13] Certainly, our own experience supports these findings, and at the time of this writing, we have demonstrated a 12% yield of detecting paroxysmal AF in our population of patients with ILRs. [14]

However, the detection yield is not uniform. Importantly, later-detected AF episodes tend to be shorter and have a lower overall burden.[1,2] This observation has raised questions regarding the embolic relevance of very low-burden AF, particularly when detected months after the index stroke.[1,8] On the other hand, the literature suggests that even paroxysmal AF episodes lasting a few minutes may have consequential emboligenic effects.[15]

These findings underscore the importance of patient selection. The highest diagnostic yield and greatest clinical relevance are observed when ILRs are deployed in patients with biological evidence of atrial disease rather than as indiscriminate screening tools.

## Atrial Cardiopathy as the Pathophysiologic Substrate

Atrial cardiopathy refers to a spectrum of atrial structural remodeling, fibrosis, conduction abnormalities, and mechanical dysfunction that predispose to thromboembolism, independent

of documented AF (Figure 4).[3-7] This construct helps reconcile several longstanding clinical observations, including embolic strokes occurring in the absence of detected arrhythmia and the imperfect temporal relationship between AF episodes and thromboembolic events. Markers of atrial cardiopathy can be broadly categorized into electrocardiographic, echocardiographic, and biomarker domains (Figure 5). [16-20]

## Electrocardiographic Markers of Atrial Cardiopathy

Electrocardiography provides readily accessible insights into atrial electrical remodeling. Prolonged P-wave duration, abnormal P-wave terminal force in lead V1, PR interval prolongation, and increased P-wave dispersion have all been associated with incident AF and stroke risk (Figure 5).[18]

These abnormalities reflect slowed intra-atrial conduction and heterogeneous atrial depolarization, hallmarks of atrial fibrosis. Importantly, several studies have shown that such electrocardiographic markers predict future AF detection on ILR. Their presence should therefore heighten clinical suspicion and support prolonged monitoring via ILR utilization (Figure 5).

## Echocardiographic Markers of Atrial Cardiopathy

Echocardiography provides structural and functional correlates of atrial disease. Left atrial enlargement remains the most widely recognized marker, but atrial cardiopathy extends beyond simple chamber size (Figure 5). Reduced left atrial appendage emptying velocity, impaired reservoir and conduit function, spontaneous echo contrast, and atrial strain abnormalities all reflect advanced atrial pathology.[19]

Left atrial strain imaging, in particular, has emerged as a sensitive marker of atrial fibrosis and dysfunction (Figure 5). Reduced atrial strain has been associated with AF detection, thromboembolic risk, and adverse cardiovascular outcomes. Patients with such findings represent a biologically enriched population in whom implantable loop recorder monitoring is more likely to yield clinically actionable information.[14]

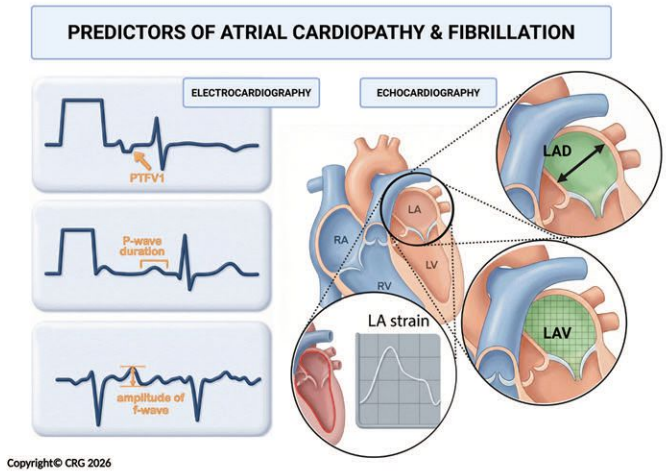



Figure 5
Electrocardiographic and imaging stigmata of atrial cardiopathy and predictors of atrial fibrillation.
LA = Left atrium; RA = Right atrium; LV = Left ventricle; RV = Right ventricle; PTFV1 = Terminal force of the P wave in the V1 lead of the electrocardiogram; LAD = Left atrial diameter; LAV = Left atrial volume

## Biomarkers and Emerging Indicators

Elevated natriuretic peptides, markers of inflammation, and indices of myocardial fibrosis have also been associated with atrial cardiopathy and AF risk.[16, 17, 20] While not yet routinely integrated into clinical decision-making, these biomarkers further support the idea that atrial disease precedes arrhythmia and may directly contribute to embolic risk.

## Predicting Monitoring Success: Selecting Patients for Optimal Results

The central clinical challenge is not whether ILRs detect AF more frequently; the existing literature supports this contention. A more operationally relevant question is: What is the clinical profile of stroke patients most likely to benefit from extended monitoring and ILR placement, those for whom such practice meaningfully alters management in which it occurs? The answer is somewhat self-evident: Patients with ischemic stroke who demonstrate electrocardiographic or echocardiographic evidence of atrial cardiopathy consistently show higher detection rates on long-term monitoring.[14]

Conversely, patients with structurally normal atria, normal P-wave indices, and no evidence of atrial dysfunction may still develop brief, low-burden AF episodes, but the clinical relevance of these findings is unclear. In these patients, long-term monitoring is fraught with the risk of identifying arrhythmias that may

represent epiphenomena rather than causal mechanisms. Thus, at least to some degree, ILR placement should be used strategically, guided by markers of atrial disease rather than solely by stroke classification schemas.

## Clinical Implications and Ongoing Controversies

An important aspect of our discussion, one we must certainly address, is the fact that despite higher AF detection rates, randomized trials have not consistently shown a reduction in recurrent stroke with prolonged monitoring. This apparent paradox likely reflects multiple logical flaws and anchoring biases, as well as the detection of lower-risk AF phenotypes, and insufficient power to detect modest differences in outcomes.[8-11, 13, 21]

These findings should not be interpreted as evidence against prolonged monitoring, but rather as an argument for refinement. The goal should not be maximal detection, but meaningful detection. Integrating atrial cardiopathy markers into patient selection may represent the key to reconciling detection yield with clinical benefit.[14]

## Future Directions

Ongoing studies are exploring anticoagulation strategies based on atrial cardiopathy rather than documented AF alone. Unfortunately, at the time of this writing, published results from studies such as the ARCADIA project predictably showed no benefit in the treatment group due to the trial's uncritical, mechanistically flawed design.[21]

That said, the current trend in clinical research acknowledges that thromboembolic risk may arise from atrial pathology itself. As these data mature, ILRs may evolve from diagnostic tools into platforms for atrial disease phenotyping and longitudinal risk stratification.

## Conclusion

ILRs represent a powerful extension of the vascular neurologist's diagnostic armamentarium in patients with ischemic stroke. Their optimal use requires a shift in perspective. AF should be viewed not as an isolated rhythm abnormality, but as a marker of atrial cardiopathy. When deployed in patients with electrocardiographic and echocardiographic evidence of atrial disease, long-term monitoring offers its greatest diagnostic and clinical value. In this context, ILRs serve not merely to detect arrhythmia but also to illuminate the underlying atrial substrate that drives embolic risk.

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## Disclosure

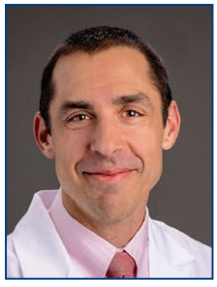
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# Beyond COSS: The Evolution of Hemodynamic Imaging and Revascularization Strategies in Chronic Cerebrovascular Occlusion

*by Fareed Jumah, MD, Hunter Brooks, MS, Farhan Siddiq, MD & Balint Otvos, MD, PhD*

MU Health Care

**Advances in tools set the stage for future randomized trials to identify patients most likely to benefit from vascular recanalization or flow augmentation.**



Fareed Jumah, MD, Hunter Brooks, MS, Farhan Siddiq, MD & Balint Otvos, MD, PhD, (pictured), are in the Department of Neurosurgery, University of Missouri, Columbia, Missouri, USA.

## Abstract

**Chronic carotid occlusion (CCO) carries a significant risk of ischemic stroke, particularly in patients with impaired cerebrovascular reserve. Extracranial–intracranial (EC–IC) bypass emerged as a popular treatment strategy with high technical success rates. However, multiple large randomized trials, including the Carotid Occlusion Surgery Study (COSS), failed to demonstrate a statistically significant benefit, mainly due to perioperative stroke risk and limitations in patient selection. Surgical revascularization declined as a result. We aim through this review to re-examine the role of flow augmentation in CCO in light of modern advances in cerebral perfusion imaging. Contemporary modalities—including computed tomography perfusion and emerging magnetic resonance techniques—allow better identification of patients with hemodynamic compromise who may be at highest risk despite medical therapy. Future studies incorporating refined imaging criteria may better define the subset of patients most likely to benefit from selective revascularization.**

## Key Words

Carotid occlusion, hypoperfusion, cerebral bypass.

## Introduction

Atherosclerotic chronic carotid occlusion (CCO) is associated with a significant risk of ipsilateral ischemic stroke, accounting for approximately 10% of TIAs and 15-25% of strokes in the carotid territory.[1-3] Since its introduction in the 1960s, extracranial–intracranial (EC–IC) bypass has emerged as an appealing revascularization strategy; however, subsequent randomized trials failed to demonstrate clinical benefit despite high technical success rates. These negative results had lead to a mainstays of therapy for CCO focused on conservative medical management. However the subsequent advances in cerebral perfusion imaging of functional cerebrovascular reserve renewed attention toward a physiologically defined subset of patients who would still benefit from flow augmentation.

This review traces the evolution of revascularization strategies for CCO, from early surgical enthusiasm to the development of novel

cerebrovascular imaging modalities, to contemporary reinterpretation and selective application.

## Pathophysiology of Chronic Carotid Occlusion

One of the most well-studied mechanisms of ischemia in CCO is hemodynamic failure.[2,4] As a result of occlusion, cerebral perfusion distal to the lesion becomes highly dependent on collaterals (e.g. from ophthalmic arteries, PcoM, AcoM, leptomeningeal vessels).[5] The capacity of these collaterals to compensate under physiologic stress is highly variable and often limited.

Under normal circumstances, cerebral autoregulation is able to initially mitigate reductions in perfusion pressure through vasodilation of distal arterioles, therefore preserving cerebral blood flow. However, as collateral capacity becomes exhausted, further reductions in perfusion pressure can no longer be compensated, resulting in a state of critical hypoperfusion. This progression is described as advancing from compensated hypoperfusion (Stage I hemodynamic failure) to decompensated hypoperfusion with increased oxygen extraction fraction (Stage II hemodynamic failure), commonly referred to as "misery perfusion."[2,4] Importantly, this hemodynamic insufficiency can be exacerbated by systemic changes (e.g. hypotension, dehydration, anemia, infection, or perioperative stress) and can manifest as fluctuating or posture-dependent neurological symptoms, watershed infarcts, or recurrent TIAs. Asymptomatic CCO carries an approximate rate of 4.4% and 3.2% annual risk of stroke and TIAs, respectively,[6] while symptomatic CCO has an annual stroke rate of 6–20%.[7,8]

## The Early Surgical Era

Recognition of these pathophysiologic mechanisms coupled with the introduction of microneurosurgery in the 1960s provided the conceptual framework for surgical revascularization. The first EC-IC bypass for ICA occlusion was performed by Yasargil and Donaghy in 1967,[9] and the procedure quickly gained popularity for treatment of steno-occlusive pathologies. Early enthusiasm, however, was driven by physiologic plausibility rather than rigorous evidence, where most studies over the following two to three decades were limited to small retrospective series describing the safety and apparent efficacy of the procedure.[10-15] These studies were highly heterogeneous with respect to patient selection, symptomatology, timing, collateral status, and stroke mechanism, and notably lacked objective assessment of cerebral hemodynamics.

The need for more rigorous evidence culminated in the International EC-IC Bypass Trial published in 1985,[16] the first prospective RCT evaluating EC–IC bypass in addition to best medical therapy versus medical therapy alone in patients with CCO. The study included 1,377 patients, with an average follow-up of 55.8 months. The trial ultimately failed to show a significant difference in the risk of subsequent stroke between the medical (29%) and surgical (31%) arms. A major criticism of this trial was the lack of quantitative measures of cerebral perfusion to identify high-risk patients who will benefit from surgical revascularization.[17,18] This key limitation paved the way for subsequent seminal investigations, most notably the St. Louis Carotid Occlusion Study (STLCOS) and the COSS trial.

The STLCOS[2] provided the first prospective evidence that cerebral hemodynamic compromise predicts stroke risk in patients with CCO. The study utilized PET imaging to quantify oxygen extraction fraction (OEF) in order to demonstrate that patients with increased ipsilateral OEF experienced a markedly increased risk of subsequent ischemic stroke, with approximately 25–30% risk of ipsilateral stroke within two years despite medical therapy. These findings were pivotal in laying the groundwork for the COSS trial.

The Carotid Occlusion Surgery Study (COSS)[19] was a prospective, randomized, open-label trial published in 2011, designed to determine whether STA–MCA bypass added to best medical therapy reduced the two-year risk of ipsilateral ischemic stroke in patients with symptomatic CCO and PET-defined hemodynamic compromise. The trial included 195 patients with recent ischemic stroke or TIA (≤120 days) and increased OEF were randomized 1:1 to medical therapy alone or medical therapy plus bypass. The trial was ultimately terminated early due to futility. Intention-to-treat analysis demonstrated a two-year ipsilateral stroke rate of 21% in the surgical group and 22.7% in the medical group ($p = 0.78$). Perioperative ipsilateral stroke within 30 days occurred significantly more often in the surgical group (14.4% vs 2.0%), resulting in no net clinical benefit of bypass in this population. There appeared to be a trend toward benefits from flow augmentation by bypass if the results of study would have been extended to five years or longer, as the yearly stroke rate for individuals who underwent bypass procedures was less than the medical management arm, but no such long term evaluation was attempted.

After the failure of COSS, the number of EC-IC bypasses for chronic carotid and MCA occlusions declined dramatically[20], although the belief within a large portion of

the cerebrovascular neurosurgical community was that a subset of patients with CCO could still benefit from flow augmentation procedures. Attention was still centered around the identification of hemodynamic cerebral ischemia and impaired cerebrovascular reserve using more widely available physiologic imaging modalities. DIAMOX-SPECT scans were a mainstay for evaluation of hemispheric hypoperfusion during times of increased cerebrovascular necessity. However, the interpretation of the DIAMOX scans was more nuanced, imperfect, and since the evaluation wasn't a change or improvement from the patient selection in COSS, positive DIAMOX-SPECT scans demonstrating Type 2 cerebrovascular reserve did not represent a new or more selective subset of patients when compared to the experimental cohort from COSS.[21]

## CT perfusion scanning and CMOSS

The modern era of cerebral perfusion imaging was shaped largely by advances in acute ischemic stroke care. Prior to 2015, treatment of symptomatic large-vessel occlusion was limited to supportive measures and secondary stroke prevention. This paradigm shifted following the publication of multiple positive randomized thrombectomy trials in 2015 (MR CLEAN, ESCAPE, SWIFT PRIME, REVASCAT, EXTEND-IA), which established endovascular therapy as standard of care within early time windows. Subsequent trials in 2018 (DAWN and DEFUSE III) further expanded eligibility for intervention up to 24 hours from symptom onset, contingent on the presence of salvageable hypoperfused tissue, thereby accelerating the need for rapid, reliable assessment of cerebral perfusion.[22-29]

Computed tomography perfusion scanning (CT-P) was developed over 15 years ago, but came into the limelight as a consequence of evaluating possible thrombectomy candidates. CTP imaging consists of an initial CT angiogram to identify major arteries and venous structures, followed by dynamic post-contrast imaging for 30-45 sec to track contrast transit through the cerebral vasculature and parenchyma. Deconvolution of this data generates perfusion maps that differentiate infarcted tissue—characterized by reduced cerebral blood volume (CBV) and cerebral blood flow (CBF)—from hypoperfused but potentially viable tissue, defined by preserved CBV with reduced CBF and prolonged mean transit time and time to peak. In general, regions of delayed contrast arrival with maintained CBV are interpreted as ischemic penumbra.[30-32] This scanning modality began to be widespread during the DEFUSE III and DAWN era, and has, until today, become the mainstay for evaluation of all pathologies of cerebral hypoperfusion, be it acute large and medium vessel occlusions, cerebral vasospasm, reversible hypoperfusion syndromes such as RCVS, sinus thrombosis, or CCO.[33-35]

CT perfusion, when utilized in planning of endovascular procedures, has improved success rates in recanalization of select CCOs. Five retrospective cohort studies from 2016–2021 utilizing CTP reported recanalization rates from 53% to 83%.[36-40] Procedures were generally well tolerated, with periprocedural complication rates ranging from 3% to 10%.. More recent series report success rates near 65%, supporting the feasibility of endovascular recanalization in the appropriate patient population. However, failure of the procedure in one in three individuals indicates that more successful management strategies would need to be employed.

Published in 2023, CMOSS was a multicenter randomized trial from 39 centers in China evaluating surgical revascularization for chronic ICA or MCA occlusion or severe stenosis using CT perfusion–based selection.[41] Patients were selected based on increased MCA-territory MTT (>4 s) with preserved CBV and reduced relative CBF, while those with poor collaterals or large established infarcts were excluded. The primary endpoint was stroke or death within 30 days or ipsilateral stroke from 30 days to 2 years. Bypass patency exceeded 93% at 2 years. Perioperative stroke or death occurred in 6.2% of surgical patients versus 1.8% with medical therapy, confirming the persistent early procedural risk.

However, from 30 days to 2 years, ipsilateral stroke rates were lower in the surgical arm (2.0% vs 10.3%), though cumulative stroke rates at study completion did not reach statistical significance. Although CMOSS failed to meet significance at its primary endpoint, several factors suggest that select patient subsets benefit from surgical revascularization, and CT perfusion represented an important step toward identifying this high-risk population.{Miller, 2015 #90} The authors themselves noted outcomes trending toward benefit, with projections indicating the trial would have been positive with five-year rather than two-year follow-up (1% vs. 5.1% ipsilateral stroke per year). Subgroup analyses further demonstrated trends favoring surgery in patients with longer intervals from last stroke, completed strokes rather than TIAs, antiplatelet use, MCA occlusions, and—most notably—marked hemodynamic compromise (MTT >6 s and rCBF <0.8).

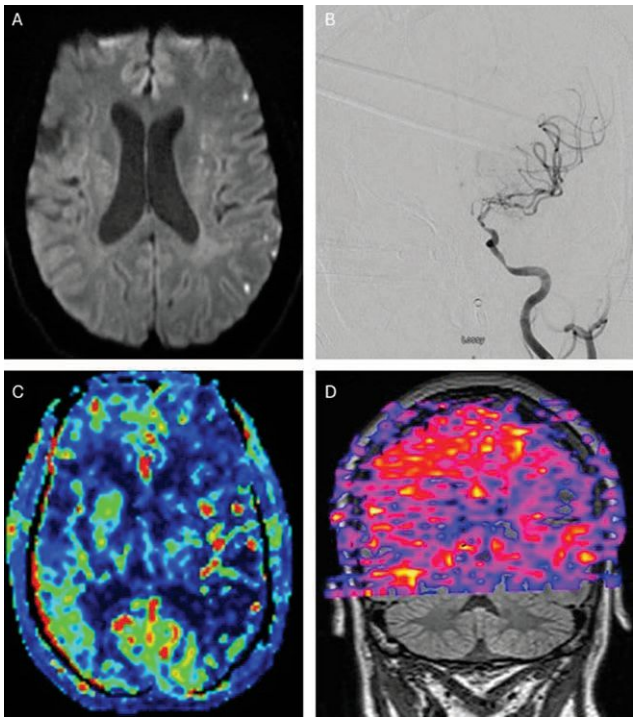



Figure 1: Use of novel imaging techniques for evaluation of revascularization. Images depict a 49 year old female presenting with recurrent TIAs who is an optimal candidate for revascularization. Diffusion weighted MRI demonstrates punctate infarcts in the left MCA watershed territory (A). Digital subtraction angiography demonstrates distal intracranial ICA and M1 near occlusions with slowed perfusion into the MCA distribution (B). Arterial spin labeling MRI demonstrates resting hypoperfusion in the left MCA territory compared to the right MCA territory (C). Breath hold MRI demonstrates decreased cerebrovascular reserve (Stage 2 hemodynamic failure) in the left MCA territory indicating insufficient collateralization and increased hypoperfusion during times of stress (D).

## Return to MRI-Based Imaging for Evaluation of Cerebral Hypoperfusion

CT perfusion is invaluable for rapid identification of salvageable tissue in acute vessel occlusion and for thrombectomy decision-making, but it cannot assess cerebrovascular reserve during stress (Stage 2 hemodynamic failure).[42] Advances in MRI now allow for measurement of relative MTT using arterial spin labeling (ASL) and more specific evaluation of cerebrovascular reserve using blood oxygen level dependent (BOLD) MRI techniques.[43-45] In a breath-hold MRI, a patient is asked to hold their breath for 30 second intervals, leading to hypercapnic vasodilatation and a BOLD signal peak in normal or Stage 0/1 vascular territories with paradoxical vasoconstriction or no effect in Stage 2 territories. Deconvolved BOLD data are displayed as heat maps over baseline MRI, enabling precise regional assessment of cerebrovascular reserve and vascular steal, outperforming Diamox-SPECT. Combined during the same scan, ASL and breath-hold MRI allow for evaluation of baseline perfusion states as well as intracerebral vascular hemodynamic failure, integrating the strengths these scans can offer independently. We and others have begun utilizing MRI to evaluate patients with moyamoya syndrome and CCO, and have successfully identified those who would benefit from revascularization (Figure 1).[46,47] The scans are accurate, well tolerated, and offer more precise resting state and stressed perfusion states than our prior imaging modalities.

## Conclusions

CCO carries a significant risk of ischemic stroke, with an annual rates approaching 10%. Although early enthusiasm for routine surgical revascularization failed to show significant benefit in clinical trials, we believe that the natural history of CCOs underscores the need for disease modulation. The results of these trials should not be viewed as definitive; rather, have emphasized the importance of careful patient selection based on cerebrovascular hemodynamics. Advances in perfusion imaging now allows for precise selection of patients with hemodynamic compromise. Modern MRI techniques have taken this a step further by measuring resting hypoperfusion and stress-induced hemodynamic failure, therefore allowing for even more precise identification of high-risk patients. These tools set the stage for future randomized trials to identify patients most likely to benefit from vascular recanalization or flow augmentation.

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NETWORK, LEARN & CELEBRATE

# 168th Annual Convention

# OFFICIAL MINUTES & REPORTS

**April 10 - April 11, 2026**
**DoubleTree by Hilton**
**Chesterfield, Missouri**



# Meet MSMA's 2026-2027 President

## Kevin D. Weikart, MD
## Lake Saint Louis, Missouri

Kevin D. Weikart, MD, FACP, is the President of the Missouri State Medical Association (MSMA) for the 2026-2027 term. He was installed April 11, 2026, during the MSMA's 176th Anniversary and its 168th Annual Convention in Chesterfield, Missouri.

Dr. Weikart was born in Kingston, New York, and moved to Lake Saint Louis, Missouri, in 1987. He is the son of Hugh and Joan Weikart. Dr. Weikart earned his Bachelor of Arts degree in Biology with a Chemistry minor from Millikin University in Decatur, Illinois. He then went on to earn his medical degree from the American University of the Caribbean in Saint Maarten. Dr. Weikart completed his residency in Internal Medicine at St. Elizabeth Hospital, which is part of Seton Hall University School of Health and Medicine, Nutley, New Jersey.

He is board certified and recertified in Internal Medicine, as well as board certified in Hospice Medicine, with additional certifications in Hyperbaric Medicine. Dr. Weikart began his private practice in Internal Medicine at Saint Joseph West Hospital in Lake St. Louis, Missouri, in 1988.

A longtime member of several professional organizations, Dr. Weikart has been a member of the American Medical Association (AMA) since 1984, the MSMA since 2001, and the American College of Physicians (ACP) since 1998, where he became a Fellow in 2002. He has represented the organized medical staff of the AMA at Saint Joseph Health Center.

Throughout his career, Dr. Weikart has served on numerous committees, including the Hospice Advisory Service, Utilization Review Committees, and the Physician-Hospital Organization (PHO) Committee. He has also been on the Medical Executive Committee for 20 years, Chair of the Physician Quality Committee, and Chief of Medicine at Saint Joseph Health Center from 2007 through 2008, and Chief of Staff there in 2020.

Dr. Weikart has been deeply involved with the MSMA, serving as both Vice Councilor and Councilor for the MSMA's 4th District for over 20 years, and as Secretary and Vice President. He has also led the St. Charles/Lincoln County Medical Society as President.

In terms of medical research, Dr. Weikart has contributed to several studies, including the Dynacirc Hypertension Study (1993), the Avapro Hypertension Study (1992), and a Hepatitis C Study (2000). He has also been involved in medical education, serving with ACES Education in affiliation with Washington University School of Medicine in St. Louis since 2003.

Dr. Weikart transitioned to a concierge medical practice in 2012, where he continues to serve patients with a high level of personalized care.

During his presidency of the MSMA, Dr. Weikart intends to focus on the rapidly changing landscape of medicine and the importance of maintaining access to quality healthcare for all Missourians. **MM**

# Alliance Installs 2026-2027 President

## Gill Waltman
## St. Louis, Missouri



Gill Waltman, 2026-2027 Alliance President, was born and raised in England, the oldest of four siblings. Her family has a strong tradition in the medical field with several generations of physicians and surgeons.

Gill, known as Professor Roper-Hall in her professional world, was educated in England and did her specialty training in binocular vision and eye movements at Moorfield's Eye Hospital in London.

She came to the United States in the 1970s to pursue a fellowship in neuro-ophthalmology at Washington University in St. Louis where she heard about a shy, very bright young cornea surgeon and former chief resident who was away at the time serving as a major in the US Army at Walter Reed Hospital.

Soon after, she and Steve Waltman were introduced at the Academy of Ophthalmology annual meeting in Las Vegas. After a short transatlantic romance with Gill back in England, she returned to Washington University to accept a position in the Department of Ophthalmology where Steve was already back on the faculty. They were married that year and later had two children; Belinda and Michael. Sadly, after 50 years of marriage, Steve passed away in 2023.

Belinda is a physician, currently the medical director of a Los Angeles County Health Department initiative for the underserved. She is married to Matt, a biophysicist and tenured professor at Caltech in Pasadena; they have two children. Michael is a business strategist, most recently a national director for Uber. He and his wife Michelle live in Connecticut and also have two children.

Gill is currently a full Professor of Ophthalmology at Saint Louis University School of Medicine. She is internationally recognized for her clinical expertise and research experience in the field of adult strabismus and neuro-ophthalmology. She is a prolific author, and an experienced reviewer. She considers herself an "ambassador" for the Saint Louis University and the profession as she travels around the US and abroad.

Gill's other activities include tennis, hiking, reading long novels, and traveling to visit family and attend conferences. She and Steve traveled extensively during their time together and visited all seven continents. Gill is a long-time board director of the Saint Louis Chamber Chorus serving as vice president and editor of its newsletter. She is the editor of two other newsletters and recently was appointed as associate editor for the AMA Alliance *Physician Family Magazine*.

Between her busy career and family responsibilities, Gill has always found time for the Alliance. She became a member in 1986 (when Chris Bohigian was MSMA Alliance president), being elected to the board a year later as the SLMMS Alliance Vice President for Health. She has served on the SLMMS Alliance board in numerous positions and held three consecutive terms as its president from 2003-2006, and as co-president from 2015-2017.

Gill has held leadership positions as MSMA Alliance Vice President for Health, Legislation, Recording Secretary, and Newsletter Editor. She served as President for two consecutive terms from 2018-2019 and 2019-2020. Gill was recently installed for her third term as MSMA Alliance President; Her theme for this year is "Shared Vision for the Future." **MM**

# 2026 Annual Convention Photo Highlights






























# Recipients of the 50-Year Physician Pin

Seventeen physicians were recognized with their 50-Year Physician pin award during MSMA's Presidential Inauguration. Congratulations to all our 50-Year Pin recipients!




50-Year Recipients, L to R: Joseph A. Corrado, MD; Marc K. Taormina, MD; Brian Biggers, MD, MSMA President; Alexander R. Hover, Jr., MD; Lawrence Lewis, MD; and Mark Ludwig, MD.

- Rakesh Chandra, MD – Carbondale, IL
- Charles F. Cockerell, MD – Blue Springs
- Joseph A. Corrado, MD – Mexico
- David A. Fleming, MD – Columbia
- James W. Gieselmann, MD – Poplar Bluff
- Harvey S. Glazer, MD – St. Louis
- Alexander R. Hover, Jr., MD – Ozark
- David Y. Lee, MD – Cape Girardeau
- Lawrence Lewis, MD – Webster Groves
- Mark A. Ludwig, MD – St. Louis
- Katherine A. Maxson, MD – St. Louis
- David R. Mehr, MD – Columbia
- Orrin A. Moore, MD – Kansas City
- Mary A. Morley, MD – Chesterfield
- Thorkild V. Norregaard, MD – Columbia
- Marc K. Taormina, MD – Lee's Summit
- Tom Weigand, MD – St. Joseph
- Timothy A. Wilson, MD – Trimble

**MM**

# MSMA Elects Leadership: 2026-2027

## Officers

**President**
Kevin Weikart, MD, Lake St. Louis

**President Elect**
Joanne Loethen, MD, Kansas City

**Secretary**
Ellen Nichols, MD, Joplin

**Treasurer**
Christopher Swingle, DO, St. Louis

**Immediate Past President**
Brian Biggers, MD, Springfield

**1st Vice President**
Matthew Meier, DO, O'Fallon

**Honorary Vice President**
Stephen Salanski, MD, Lee's Summit

**Honorary Vice President**
John Memken, MD, Hannibal

**Speaker**
Laurin Council, MD, St. Louis

**Vice Speaker**
George Mansour, MD, St. Louis

## Councilors

**Council Chair (3rd District)**
Elie Azrak, MD, St. Louis

**Council Vice Chair, (7th District)**
David Kuhlmann, MD, Sedalia

**1st District**
Chakshu Gupta, MD, St. Joseph

**2nd District**
Barbara White, DO, Hannibal

**3rd District**
Erin Gardner, MD, St. Louis
Jenny Page, MD, St. Louis
Inderjit Singh, MD, St. Louis

**4th District**
Keith Ratcliff, MD, Washington

**5th District**
Lisa Thomas, MD, Lake Ozark
Amy Zguta, MD, Columbia

**6th District**
Dorothy Munch, DO, Poplar Bluff
Lirong Zhu, MD, Clayton

**7th District**
Amy Patel, MD, Kansas City
Blake Cooper, MD, Kansas City

**8th District**
Timothy Swearengin, DO, Springfield

**Organized Medical Staff Section**
Peggy Barjenbruch, MD, Mexico

**International Medical Graduate Section**
Deepu Sudhakaran, MD, Chesterfield

**Young Physician Section**
Rachel Kyllo, MD, Arnold

**Women Physicians Section**
Adriana Canas-Polesel, MD, St. Louis

**Resident & Fellow Section**
Jay Devineni, MD, Kansas City

**Medical Student Section**
Miranda Mize, Washington University

## VICE COUNCILORS

**2nd District**
Valena Fiscus, DO, Kirksville

**3rd District**
Ramona Behshad, MD, St. Louis

**4th District**
Matthew Meier, DO, Lake St. Louis

**5th District**
Jennifer Powell, MD, Osage Beach

**7th District**
Sarah Florio, MD, Lee's Summit

**8th District**
John Harger, MD, Clever

**International Medical Graduate Section**
Louis DelCampo, MD, Springfield

**Young Physician Section**
Sara Hawatmeh, MD, St. Louis

**Women Physicians Section**
Carlin Ridpath, MD, Springfield

**Resident & Fellow Section**
Lacey Capetti, MD, Columbia

**Medical Student Section**
Sreya Mandava
University of Missouri-Kansas City

## AMA Delegates & *Alternate Delegates

Elie Azrak, MD, St. Louis
Peggy Barjenbruch, MD, Mexico
Joseph Corrado, MD, Mexico
Betty Drees, MD, Kansas City
Ravi Johar, MD, Chesterfield
Charles Van Way, III, MD, Kansas City

* Brian Biggers, MD, Springfield
* George Hruza, MD, Chesterfield
* Ravi Johar, MD, Chesterfield
* Joanne Loethen, MD, Kansas City
* Samantha Shuster, Kansas City University

## AMA Past President

David Barbe, MD, Mountain Grove

## *Alliance*

**President**
Gill Waltman, St. Louis

MM

# 2026 Resolutions & Actions

### Resolution 1: On-Site Physician Availability in Emergency Departments

*Action: Amended Resolution Adopted*

RESOLVED, that the MSMA delegation to the AMA House of Delegates support a resolution to encourage the AMA to advocate for the indefinite extension of telemedicine reimbursement waivers scheduled to sunset on September 30, 2025.

### Resolution 2: Telemedicine

*Action: Substitute Resolution Adopted*

RESOLVED, that the MSMA delegation to the AMA House of Delegates support a resolution to encourage the AMA to advocate for the indefinite extension of telemedicine reimbursement waivers scheduled to sunset on September 30, 2025.

### Resolution 3: Standardized Pricing and Formulary Access for Compassionate Prescribing of Opioids in Palliative Care

*Action: Amended Resolution Adopted*

RESOLVED, that the Missouri State Medical Association (MSMA) advocate for standardized pricing policies and equitable formulary access for core opioid medications used in compassionate prescribing for patients with serious illness, especially those in palliative care settings as these medications are provided through the hospice Medicare benefit, but are only available through a prescription plan for palliative care patients; and be it further

RESOLVED, that MSMA support federal and state policy initiatives aimed at improving drug pricing transparency, reducing nonmedical formulary switching, and enhancing physician access to real-time cost information at the point of prescribing; and be it further

RESOLVED, that MSMA support initiatives to require insurance companies to have affordable coverage policies (same tier pricing, or fixed copay like insulin) for compassionate opiate prescriptions; and be it further

RESOLVED, that MSMA encourage regulatory bodies to monitor and address the impact of drug shortages and insurance denials on high-risk prescribing practices, including the burden on physicians and the safety of patients who require uninterrupted opioid therapy for pain management; and further, that MSMA advocate that these bodies investigate, understand, and seek to resolve or report shortages in palliative opioids that disrupt patient quality of care, threaten the continuity of care, and place additional prescribing and administrative burdens on physicians.

### Resolution 4: Review of Past Resolutions

*Action: Substitute Resolution Adopted*

RESOLVED, that the MSMA delegation to the AMA House of Delegates support a resolution to encourage the AMA Board of Trustees to present a detailed and aggregate report that is easily accessible and includes at least the past ten years of data regarding the number of resolutions submitted to the AMA House of Delegates at both annual and interim meetings, the number of resolutions specific to advocacy on medical practice sustainability, and the percentage of resolutions that have been implemented.

### Resolution 5: Annual Scorecard to Evaluate the AMA's Impact

*Action: Substitute Resolution Adopted*

RESOLVED, that the MSMA delegation to the AMA House of Delegates support a resolution asking the AMA to implement a comprehensive scorecard to measure its effectiveness in key areas.

### Resolution 6: Supporting and Promoting (Appropriate) AMA Member Physicians and Physician Spouses as Candidates for Local and State Offices

*Action: Substitute Resolution Adopted*

RESOLVED, that the MSMA delegation to the AMA House of Delegates support a resolution asking the AMA to study the feasibility of collaborating with state medical societies and specialty societies to identify physicians and physician spouses running for state and local offices, and that this information be used to support physicians and physician spouses who are aligned with organized medicine's priorities; and be it further

RESOLVED, that the MSMA delegation will forward this resolution to the AMA House of Delegates.

### Resolution 8: Hospital Internal Temperatures

*Action: Resolution Not Adopted*

RESOLVED, That our MSMA will ask the AMA to persuade TJC (and other hospital accreditation organizations) to create a mandatory standard for hospitals' common area internal temperatures, to be regularly monitored in those hospital common areas, toward enabling both fuel and monetary savings that would accrue if hospital common area internal temperatures were not kept at levels that require visitors to bring extra clothing to the hospital to enable their comfort while visiting patients.

### Resolution 9: Supporting Legislative Efforts to Protect Children from Harmful Custody Proceedings

*Action: Resolution Adopted*

RESOLVED, that our MSMA support legislative efforts to strengthen child custody laws in a manner that prioritizes child safety in cases of family violence, including but not limited to the use of qualified expertise, evidence-based practices, trauma-informed training, and consideration of prior abuse in child custody cases.

### Resolution 10: Medical Record Access to Aging Out Foster Youth

*Action: Amended Resolution Adopted*

RESOLVED, that the MSMA supports efforts to mandate state child welfare agencies to provide foster youth with a complete and portable medical record summary upon aging out of care; and, be it further

RESOLVED, that our MSMA encourages the use of electronic health record (EHR) systems and inter-agency data sharing to ensure foster youth maintain access to their medical histories after transitioning to adulthood.

### Resolution 11: Advancing Aging Medicine

*Action: Substitute Resolution Adopted*

RESOLVED, that the MSMA support programs that support longevity healthcare, and enhance patient education, early detection, and treatment of age-related diseases.

### Resolution 12: Missouri Health Care Stabilization Fund Ad-Hoc Committee

*Action: Resolution Adopted*

RESOLVED, that MSMA assemble an ad-hoc committee to:
1) Investigate the feasibility of establishing a Missouri health care stabilization fund, and
2) Provide recommendations to the MSMA Council.

### Resolution 13: Continuity of Care for Rural Patients

*Action: Resolution Not Adopted*

RESOLVED, that denial of phone access to higher level medical centers' specialists, after being requested by rural emergency physicians, must become classified as an unethical abandonment of the patient and their needs, which must become proscribed by new laws or regulations that could be adopted by leaders or legislators of the various states; and, be it further

RESOLVED, that specialist physicians at higher level medical centers who may not have the opportunity to participate in or guide care of these patients after their transfer from a rural hospital may have an understandable medico-legal concerns that merit becoming addressed in a manner similar to the protections offered by "Good Samaritan" laws which exist in the various states of the United States; and, be it further

RESOLVED, that such laws or regulations should be created to protect these specialist physicians, whose advice is crucial to optimal patient management; and, be it further

RESOLVED, that this organization will create model legislation to address these two linked issues of patient abandonment and specialists' medico-legal concerns, and then advocate for adoption of such legislation or regulations in each of the various states of the United States, to best protect the interests of and health of rural patients with complex medical needs, while optimizing access by rural emergency physicians to the professional guidance that can best be provided by a specialist from the group providing these patients' care for their complex medical needs. **MM**

# Summary of Council Actions: 2025-2026

## Meeting of April 7, 2025 – University Plaza Hotel, Springfield, Missouri

Joanne Loethen, MD, Kansas City, was elected Chair of Council; Elie Azrak, MD, St. Louis, was elected Vice Chair of Council; M. Ellen Nichols, MD, Joplin, was elected Secretary; Christopher Swingle, DO, St. Louis, was elected Treasurer.

## Meeting of July 13, 2025 – Courtyard by Marriott – Jefferson City, Missouri

MSMA President Brian Biggers, MD, reported on his attendance at the AMA Annual Meeting in Chicago and meetings with state legislators Melanie Stinnett, Alex Riley, and Brian Seitz regarding MSMA's advocacy efforts. He also represented MSMA at the White Coat ceremonies at both the Kansas City and Joplin campuses of Kansas City University.

### *Advocacy*

MSMA members were encouraged to use the 2026 Legislative Review as a member recruitment tool and highlighting the $150 Summer Special dues rate offered to non-members. MSMA lobbyists will be traveling throughout the state to meet with legislators in their home districts.

MSMA joined as a plaintiff in a suit against Multiplan, which has been accused of conspiring to eliminate price competition in the market for out-of-network services and artificially suppressing reimbursement. There is no cost to MSMA for joining this suit. MSMA also received an update on the Senate Insurance Committee hearing on the MU Health-Anthem contract dispute.

The Committee discussed the activities of the Missouri Board of Registration for the Healing Arts, and congratulates MSMA Councilor Dorothy Munch, DO, on being elected Chair of the Board. The AMA and MSMA has teamed up for the "Your Care is at Our Core" campaign, aimed at physician reputation rehabilitation.

### *Membership*

MSMA membership dues for 2026 are unchanged from 2025: Active members - $450; Third year practice - $300; Second year practice - $200; Affiliate members - $175; Retired members - $75; First year practice – free; New Licensee – free; Residents and Fellows – free; and Students – free.

### *Governance Pilot Project*

The MSMA Governance Pilot Project is continuing. Thirteen resolutions have been submitted and will be posted for member comments. The Medical Student section reported that it has had two cycles of the medical student resolution committee, with approximately two students from each of the medical schools participating. They have seen an improvement in the quality of medical student resolutions.

### *Consent Calendar*

- Actions and Recommendations from the 2025 Annual Meeting
- Report of the Commission on Continuing Education
- Report of the MSMA Delegation to the AMA
- Report of the Policy Review Committee
- Report of the Conflict of Interest Committee

### *Councilor Advisor Appointments*

- Commission on Medical Economics – David Kuhlmann, MD
- Commission on Continuing Education – Louis DelCampo, MD
- Commission on Public Health – Lirong Zhu, MD
- Physicians Health Committee – Lisa Thomas, MD

### *American Medical Association*

Elie Azrak, MD, gave an update on the activities of the AMA, and recognized the efforts of the AMA delegation, as well as the work of Drs. Sudhakaran and Devineni at the AMA. The Heart of America Caucus, which comprises Missouri and Kansas, is small but very active and brings a lot of common sense to the AMA House of Delegates. Dr. Azrak recognized and thanked Charles Van Way III, MD, for his report on the proceedings of the AMA meeting, which is included in the meeting materials.

### *MSMA Headquarters*

The renovations at MSMA Headquarters, a 155-year-old building, are almost finished with windows replaced, and the parking lot being repaved.

### *Alliance*

Alliance President Donna Corrado thanked Jeff Howell, Liz Fleenor, Bill Drees and Gill Waltman for making it possible to have the Alliance meeting and social gathering at MSMA headquarters. She encouraged all spouses to join the Alliance. She and MSMAA President Elect Gill Waltman ceremonially presented a check to the Missouri State Medical Foundation for $8,250, representing funds raised by the Alliance in the past year. Thanks go to Gill Waltman for spearheading the annual Holiday Sharing Card fundraiser.

## Meeting of July 19, 2025 – Courtyard by Marriott – Jefferson City, Missouri

MSMA President Brian Biggers, MD, reported he has attended several political fundraisers recently and plans to attend the Republican Senate retreat at Big Cedar Lodge at the end of October. Medical schools and residency programs are expanding in southwest Missouri. Other future activities include a trip to Washington, D.C. in November for the AMA meeting and attending the Lake area physicians meeting in December.

Joanne Loethen, MD, encouraged everyone to register for Physician Advocacy Day in March 2026, as well as Doctor of the Day. She commended MSMA lobbyists Jacob Scott and Rachel Bauer for their work on Saturday's advocacy workshop, which had more than 40 participants. They will be happy to come and give legislative updates in your district.

She reported that 50-60% of MSMA leadership contributes to MMPAC. Contributions to individual candidates are good, but it is important to have a strong PAC.

### *Advocacy*

The Legislative Committee received an update on the Rural Health Transformation Project and scoring process. MSMA has submitted a proposal to the State of Missouri for funding for student loan repayment for residents who stay and practice in Missouri for five or more years upon completion of residency.

The Committee also discussed strategies for the next legislative session utilizing national victories in title protection and restrictive covenants as well as being even more defensive with measures relating to scope of practice.

An update on the lawsuit involving Marcy Markes vs. Andrew Bailey regarding collaborative practice agreements was given.

The Committee discussed international medical graduate issues and recommends that the Council direct MSMA to establish a task force to look at many issues surrounding IMGs and how to proceed. There was discussion regarding what other states are doing to offer additional pathways for IMGs and identified other IMG issues such as parity and visa issues. There was also discussion on the $100,000 fee that was recently implemented for H-1B visas, which will impact physicians. A task force would allow MSMA to have a unified and thoughtful response.

### *Governance Pilot Project*

Thirteen resolutions were submitted by the deadline in July, with members making online comments in August and September. Committees will meet to make recommendations, followed by another opportunity for members to comment before the Council disposes of the resolutions in January.

### *MSMA Headquarters*

MSMA gave an update on the headquarters building renovations. The Association hosted fundraiser receptions in September, and several legislators indicated that they would like to hold future events in our building. We have also had new windows installed throughout the building, largely funded by a grant from the National Park Service Historic Revitalization funds. We are hoping to get the parking lot paved in concrete by the end of the year.

### *Your Care is at Our Core Campaign*

The "Your Care is at Our Core" campaign is underway and is aimed toward reframing the perception of physicians. We will be taking photos and making videos with members after the meeting, and a PR firm has been hired to help us with that effort. Social media posts will be boosted, and a micro-site will be set up to drive people toward that information, with the opportunity to join MSMA.

### *Missouri Medicine*

Lizabeth Fleenor, Managing Editor, reported that the Committee on Publication had researched answers to Resolution 17 – Creating an Opt-in System for the Paper Version of *Missouri Medicine*, in regard to budget, conservation and member preferences. She outlined recommendations for print and online journals, as well as how to boost advertising revenue. MSMA will create an opt-out system for *Missouri Medicine*, through which dues-paying members would receive a printed copy with the option to opt-out of a printed copy by contacting MSMA or changing their profile choices in their account through MSMA's website. The Council also discussed minimum copy requirements of the printer, online indexing, and the effect of opt-out versus opt-in on the ability to budget.

### *American Medical Association*

Edmond Cabbabe, MD, discussed the topic of AMA membership, which has increased despite the decrease in state society memberships. He stated that he has been placed on the AMA's Resolution Committee, which reviewed more than 140 resolutions that were submitted to the AMA House of Delegates. His term will end this year, and this will be his last AMA House of Delegates meeting. The AMA has studied establishing a new Employed Physician Section, which will cost approximately $500,000 annually for staffing and meeting expenses. Dr. Cabbabe participated in an online presentation from the St. Louis Metropolitan Medical Society regarding physician unionization.

Dr. Loethen recognized Dr. Cabbabe for his long-standing representation at the AMA. He has served since 2006 and has been on the Long-Range Planning and Development Committee. He has been an excellent resource for MSMA, and his wife Rima has been supportive. The group offered a round of applause.

### *Consent Calendar*

- Report of the Commission on Continuing Education
- Report of the MSMA Delegation to the AMA
- Report of the Missouri Physicians Health Foundation
- Report of the Policy Review Committee

### *Alliance*

Donna Corrado offered updates of recent activities, including several Physician Family Day events in August: Columbia (new), Kansas City (new), St. Louis (their second) and Springfield, which is held at the Dickerson Park Zoo and was attended by approximately 450 people. September 17 is Physician Suicide Awareness Day. Missouri recently hosted a virtual North Central States meeting, with the theme of "Uncluttering Our Lives So We Can Unclutter Our Minds."

In November, AMAOPS (the Auxiliary to the Missouri Association of Osteopathic Physicians and Surgeons) will have its last meeting with the theme of "Petals of Legacy," and then will close down the organization. Some of the DO spouses have already joined MSMAA.

## Meeting of January 17, 2026 – via Videoconference

MSMA's President Brian Biggers, MD, reported on his activities as he attended the Republican Senate Caucus at Table Rock Lake, the interim meeting of the AMA in November in Washington, D.C., and a December Lake of the Ozarks Holiday Cruise Party with his wife. In January, he visited the medical school expansion building in Springfield.

While in Washington D.C., Dr. Biggers, along with George Hruza, MD, were able to discuss the Rural Health Transformation Program, as well as plans to reduce drug and insurance costs with Robert F. Kennedy, Jr., and Mehmet Oz, MD, in the company of several other physicians from across the country.

### *Advocacy*

The legislative session has begun, and our lobbyists continue to advocate for physician interests, representing both MSMA and MAOPS. Dr. Biggers encouraged everyone to volunteer for the Doctor of the Day program, and to sign up for Physician Advocacy Day in March. A record was made with 2,237 bills filed, with more than 500 of which affect the practice of medicine.

The Committee learned about Missouri's application for Rural Health Transformation Program funds, which resulted in an award of $216 million this year. The total award is approximately $1 billion over five years. The award locks Missouri into several

things, including participation in the PA compact, a review of the scope of practice in Missouri, and support of SNAP benefit changes to exclude certain non-nutritious items from being eligible for purchase. There is also a requirement that physicians complete one hour of nutrition CME to be licensed.

The Kansas City Center for Bioethics has in the past administered the Transportable Physician Orders for Patient Preferences (TPOPP) program. They no longer have the capacity to do this. The Kansas Medical Society has taken on the management of education and forms on the Kansas side, and MSMA has been asked to do the same for Missouri. Staff is determining what infrastructure will be needed to provide administrative oversight. This will begin later this summer.

The Health Care Stabilization Fund task force has been established following the approval of the resolution at the October Council meeting. The task force will be modeled after Kansas, and Mr. Howell is asking for volunteers to serve.

The AMA has announced the Advocacy Accelerator grant, and MSMA has applied for that grant.

Rachel Bauer, MSMA Staff, was recognized for co-presenting at the AMA Scope of Practice Summit, which was held in conjunction with the AMA meeting in November. She also recognized Dr. Rachel Kyllo for being part of a panel on scope of practice at the AMA State Advocacy Summit.

Dr. Loethen acknowledged Jacob Scott for his work on restructuring our MMPAC donor levels, which has resulted in increased MMPAC donations as well as an increase in average amount per donor. She thanked everyone who has donated and pointed out that MMPAC giving is more important than ever in this election year.

### Governance Pilot Project

Because of the Governance Pilot Project, there will be no House of Delegates at the 2026 Annual Convention. The agenda provides ample time for networking with friends from across the state. Members are encouraged to visit MSMA's website for programming. The resolution timeline for next year begins on March 1, 2026, with the start of the resolution submission period. All resolutions should be disposed of by the October Council meeting. The RFS will collaborate with the MSS for a resolution-writing workshop on February 3.

This is the first time MSMA has passed resolutions without a House of Delegates. If you have feedback on this process, please reach out to Jeff Howell. The pilot project will end in a couple of years, at which time we will decide whether to continue with this process or return to a House of Delegates.

The Annual Convention is April 10-12, with the Council meeting taking place on Sunday morning, April 12.

A nominating committee was formed to decide candidates for vice presidents, the AMA delegation, the Missouri State Medical Foundation board, and the Physician Health Foundation board. The committee comprises Valena Fiscus, DO, Hannibal; James Kelly, MD, Kansas City; Benjamin Cook, DO, Jefferson City; James Blaine, MD, Springfield; and Jay Devineni, MD, Kansas City.

### Membership

MSMA asked Council to review sign-on letters included in the meeting materials, as well as read an article regarding the future of medical societies.

### Consent Calendar

- Actions and Recommendations on Resolutions from the 2025 Annual Meeting
- Report of the Publication Committee and Editorial Board
- Report of the AMA Delegation
- Report of the Physician Unionization Task
- Report of the IMG Task Force

### Alliance

Donna Corrado, President, thanked everyone who donated to the Missouri State Medical Foundation via the Holiday Sharing Card. Mrs. Corrado reported that Debbie Barbe presented a new project at the Greene County Medical Society Alliance meeting in November, "A Light in the Window." This program involves placing a light in the window for anyone that the family is waiting on – a physician spouse, a weary traveler, etc. Buchanan County Medical Society Alliance has continued its "Hands Are Not for Hitting" and "Stop the Bullying" programs. **MM**

# Official Convention Minutes & Reports: 2025-2026

## Report of the Secretary

The Missouri State Medical Association had 3,926 members at the end of the 2025 dues year (August 31, 2025). This was a net loss of 545 members from our membership of 4,471 as of August 31, 2023. Following is a breakdown according to classification.

| Year | Students | Residents | Active | Honor | Total |
|---|---|---|---|---|---|
| 2024 | 1,674 | 653 | 1,866 | 278 | 4,471 |
| 2025 | 1,504 | 560 | 1,600 | 262 | 3,926 |

The number of member deaths reported during 2025 totaled seven.

The Committee on Nominations, which is appointed by the President, must submit nominations for the following offices:

Vice President to fill the expired term of David Haustein, MD, Springfield.

Two Delegates and Four Alternate Delegates to the AMA to fill the vacancies created by the expiration at the conclusion of the 2026 Annual Convention of the terms of Delegates: Edmond Cabbabe, MD, St. Louis; Joseph Corrado, MD, Mexico; and Alternate Delegates: George Hruza, MD, Chesterfield; Ravi Johar, MD, Chesterfield; Joanne Loethen, MD, Kansas City; and Lacey Capetti, University of Missouri-Columbia (one-year term). The new two-year terms will begin at the conclusion of the 2026 MSMA Annual Convention and end at the conclusion of the 2028 MSMA Annual Convention.

The terms of the following Councilors will expire in 2026: 3rd District – Inderjit Singh, MD, St. Louis; 5th District – Lisa Thomas, MD, Lake Ozark; Amy Zguta, MD, Columbia; 6th District – Lirong Zhu, MD, Clayton; 7th District – Joanne Loethen, MD, Kansas City; Blake Cooper, MD, Kansas City; Organized Medical Staff Section – Peggy Barjenbruch, MD, Mexico; International Medical Graduate Section – Louis DelCampo, MD, Springfield; Resident and Fellow Section – Jay Devineni, MD, Kansas City; Medical Student Section – Taylor LaValle, University of Missouri - Columbia..

The terms of the following Vice Councilors will expire in 2026: 3rd District – Ramona Behshad, MD, St. Louis; 5th District – Jennifer Powell, MD, Osage Beach; 7th District – Sarah Florio, MD, Lee's Summit; International Medical Graduate Section – Deepu Sudhakaran, MD, Chesterfield; Resident and Fellow Section – Alex Shimony, MD, St. Louis; Medical Student Section – Bethany Baumgartner, Kansas City University.

Members shall meet virtually or by email prior to the Annual Convention to elect the Councilors and Vice-Councilors for their respective districts and sections.

MSMA will hold an All-Member Business Meeting on Saturday, April 11, at 9:00 a.m.

Registration will take place online at msma.org/convention and in-person at the Annual Convention from 3:00-7:00 p.m. on Friday, April 10, and 7:00 a.m.-5:00 p.m. on Saturday, April 11.

## Report of the Treasurer

The report of the Treasurer which includes the Financial Statements are published in this section of the Official Convention Minutes and Reports.

## Report of the Executive Vice President

You should be proud that your Missouri State Medical Association is widely recognized as the voice of medicine in Missouri. Be it the Missouri General Assembly, the countless governmental bureaus and agencies, the business community, the insurance industry, hospitals, advocacy groups, or the media, MSMA is considered the leading advocate for your profession and your patients. Following is just a sample of the many things your MSMA did for you in 2025.

### *State Legislative Activities*

Your MSMA lobbying team enjoyed a very good year in the state Capitol in 2025.

They are quick to credit you and your MSMA colleagues with much of that success, not only for your active involvement in the political process, but also for the respect you command in your community. MSMA's three registered lobbyists and three contract lobbyists are involved in more legislative healthcare issues than any other organization in the state: everything from scope of practice to tobacco, and tort reform to physician licensure. In October 2024, MSMA entered an agreement to provide lobbying services to the Missouri Association of Osteopathic Physicians and Surgeons. Your lobbyists are among the first to arrive at the Capitol every morning, and among the last to leave at night. Their diligence and effectiveness is unsurpassed. Rather than overwhelm you with details on the myriad bills and issues they work on, I'll refer you to our weekly *Legislative Report* and *5 Things MSMA Members Need to Know About the State Legislature*, which members receive during the legislative session. If you are not reading these e-publications, you're missing out.

### *Other Notable Activities*

Despite only having the resources and numbers of a smaller-sized state medical association, your MSMA is one of the most diverse and active state organizations in the nation. Here are just a few of the activities undertaken on your behalf over the last year.

Your President and MSMA staff were able to attend several local society meetings across the state. From Cape Girardeau to Springfield, and from St. Joseph to St. Charles, your leadership and staff continue to make themselves available to every local society and medical staff, no matter how large or small.

MSMA boasts an outstanding group of member physicians who give the better part of a week twice a year to represent you and your patients in the AMA House of Delegates. It is thankless work at times, but there is not a better AMA delegation than yours. Please thank them.

In addition to its regular duties, your MSMA staff also provides top-rate administrative services for other medical societies and serves on or maintains liaisons with a large number of external governmental and private-sector committees, task forces, boards and commissions. In 2026, MSMA is providing administrative services to the Missouri State Orthopaedic Association, the Missouri Society of Gastroenterology, and the St. Louis Metropolitan Medical Society.

### *Membership Services and Benefits*

Your MSMA staff and leadership are constantly striving to bring even more value to your membership. One constant priority is to improve communications with our members and respond more quickly to answer questions and resolve issues. We encourage you to visit the MSMA website often. More content is constantly being added, with more timely information to help you and your office staff. A few years ago, MSMA migrated to a new association management system, and a new user-friendly membership database. Also, you can now pay membership dues online and access our membership database to search for your physician colleagues. You can also make donations to MMPAC and MSMF. Look for a transition to a new website layout in the coming year.

*Missouri Medicine*, MSMA's outstanding award-winning scientific journal, is free to you with your membership. It is published in digital format as well as the traditional paper copy. Disseminated world-wide, *Missouri Medicine* is indexed by PubMed, MEDLINE, PubMed, ProQuest, Index Medicus, and Scopus. Since 2010, complete issues are archived at PubMed Central. Content appears on EBSCO Research Databases. With a large, respected editorial board and regular participation by Missouri's six medical schools on eight campuses, *Missouri Medicine* is regarded widely as among the country's top three state medical journals. You can find current and archived electronic editions on our website.

*Progress Notes*, our quarterly newsletter (free to members), is chock-full of timely news items, tips, and information. An electronic version, *eProgress Notes*, is distributed bi-monthly by email.

MSMA also offers you free CME credits at the Annual Convention every year.

I would ask you to also be mindful of the more direct benefits your MSMA membership offers. For example, we are partners with Moneta, an outstanding financial services firm that provides MSMA members with expert financial planning and investment services. SHINE is a health information exchange (HIE) which facilitates electronic medical records software sharing clinical information with other EMRs in addition to aiding with MIPS compliance. The Resolve Agency assists physicians and residents with employment contract review and modification.

### *MSMA's Affiliate Organizations*

Your Missouri State Medical Foundation has loaned more than $12.1 million to Missouri medical students since its inception more than fifty years ago. The Foundation board made the decision in 2017 to cease its loan program due to the number of private lenders in the market. The focus is now on scholarships for Missouri medical students. In 2025, MSMF awarded $330,000 in scholarships to 60 medical students at all six of the allopathic and osteopathic medical schools in the state. And the Foundation offers $5,000 matching funds to local medical societies to create scholarships for medical students. Physicians can donate to the Foundation on the MSMA website.

Your Missouri Physicians Health Program was widely considered one of the most successful of its kind in the nation. Last year the program served 71 physicians who are dealing with chemical, emotional, or behavioral issues. Unfortunately, the program suffered from a large decrease in donations post-pandemic and its operations terminated in early 2025. All participants were successfully transferred to Missouri's other two physician health programs. The Missouri State Medical Association Physician Health Foundation, which oversaw the MPHP, remains active and will seek other opportunities to support physician mental health and well-being.

Your Missouri Medical Political Action Committee is one of the most respected and effective association PACs in the state. In the last election cycle MMPAC contributed close to $100,000 to support physician-friendly candidates across the state. Membership begins at $50, but you can demonstrate your political savvy by upgrading to one of the advanced giving levels: MMPAC Ambassador ($250), Rotunda Club ($1,200), or the 1850 Society ($1,850). Members in these levels receive special privileges. Of course, any amount is appreciated. You can now donate to MMPAC through PayPal or the MSMA website. Your participation is essential to our political effectiveness.

Your MSMA Insurance Agency was formed by MSMA and was directed by physicians to serve you and your practice. In 2024, the Agency entered a co-marketing agreement with Wallstreet/Acrisure to expand its insurance product and services portfolio. This agreement provides some financial support for MSMA. The corporate structure of the Agency was terminated in 2025. Please contact rstaggs@wallstreetins.com for more information.

The MSMA Alliance has dedicated and enthusiastic physician spouses who work tirelessly to promote health education and support health-related charitable activities, all toward improving the health and welfare of all Missourians. And they are a force to be reckoned with when they march on the Capitol every year to advance medicine's legislative causes. They are also a great group of fundraisers for the MSMF.

### *Your Organization*

It is nearly impossible to list all the duties and services MSMA provides for the physicians of Missouri. The advocacy and representation, the publications, the CME, the Foundation, the Physicians Health Foundation, the Alliance, and your AMA Delegation all cumulate in an organization deeply rooted in service to its members and the patients they serve. The MSMA is YOUR organization, and your officers and staff welcome your thoughts on how best to serve you and your fellow members. Feel free to seek them out —at this convention or at any time—and share your ideas.

### *Heartfelt Thanks*

On behalf of the staff and the entire MSMA membership, I want to express undying gratitude for your officers, councilors, committee members, and other leaders who give so much of their time and resources for the betterment of the Association and patient care in Missouri. They are nothing short of extraordinary.

I also want to express my appreciation for allowing me to work with talented and dedicated MSMA employees whose creativity and diligence are unmatched anywhere. Liz Fleenor, the Director of Communications, is the managing editor of your award-winning *Missouri Medicine* and *Progress Notes*, designs all the MSMA pamphlets and logos you see, and oversees MSMA's website. Benita Stennis, the Director of Operations and Education, does all our meeting planning—including the Herculean task of organizing the Annual Convention—and also directs all aspects of CME programming. She also manages the Missouri Gastroenterology Society and SLMMS. Rachel Bauer, your Director of Government Relations, spends her springs in the Capitol advocating for your best interests. She also manages two sections and the MSMA Legislative Committee. She works closely with the Dept. of Health and the MO HealthNet Division. Our Executive Services Specialist, Cheri Martin, keeps the office running like a well-oiled machine, day in and day out. She also manages MMPAC's day-to-day activities, as well as MSMF and MSOA, and she serves as liaison to the Women Physicians section. Cassie Williams, the Membership Data & IT Specialist, tends to our complicated member database and coordinates all the membership billing and mailing for MSMA. She's the one you want if you need to know if someone has paid their dues. She spends a lot of time helping with the meeting planning and she's the go-to person when anybody on staff needs a little extra help. Jacob Scott is your Director of Legislative Affairs. He is an advocate for you in the Capitol and a well-regarded healthcare policy guru. If you want to know the political skinny in Missouri, he's the guy you need to talk to. He's also the liaison to the Resident and Fellow, IMG, and Medical Student sections, as well as the Board of Healing Arts and Dept. of Insurance.

And finally, please allow me to thank you, the physicians of Missouri, for the opportunity to serve you in this outstanding organization.

## Report of the MSMA Alliance

During the 101st Alliance Annual Meeting, the group welcomed Ron Jaggers, the first male president of the American Medical Association Alliance, from Charlotte, NC.

In March is the highlight of every year as the Alliance engaged with the medical students at Match Day events across the state—two in Kansas City, one in Joplin, one in St. Louis, and one in Columbia. A special thank you to Millie Bever, her daughter Melody, Sandra Murdock and Allene Wright for handling all the details of these important events introducing the medical students to us. It is our opportunity to show them the community of medical societies and alliances available to them wherever they go.

There are currently four Alliances: Buchanan County, Kansas City Metropolitan Medical Society, Greene County, and St. Louis Metropolitan Medical Society. In May, President Donna Corrado traveled from one side of the state to the other in July visiting county Alliances.

Also, during the July Council meeting in Jefferson City, the Alliance hosted a gathering of MSMA members, toured the newly-renovated MSMA headquarters and showcased the $8,240.51 raised by the Alliance for the Missouri State Medical Foundation.

By August, the Alliance had begun the plans for the Physician Family Days to be celebrated in Kansas City, hosted by Sana and Dr. George Saleh; St. Louis with Samantha Karlin and Zoe Taylor; Springfield with Barbara and Dr. Alex Hover; and this year, for the first time, one in Columbia with the Corrado's hosting.

This past year has been a journey of changes. The MSMA itself has changed its format and its timing. Unchanged, however, is MSMA's very way of carrying out the business of safeguarding and promoting the sovereignty of physicians as

the head of the healthcare team and promoting patient-centered legislation and legislators.

Jana Wolfe, who continues to keep the Alliance updated in the social media department and is the Membership Vice President, has moved from AMAA to AHEI. The Alliance is very proud of her.

One of the President's most treasured experiences was that of attending the final celebration of the Auxiliary of the Osteopathic Physicians and Surgeons of Missouri. Their accomplishments and history mirrored our own. The dignity and humor, humility and reality of that gala were visceral, but hopefully, not prophetic.

On the national level, as an organization, the Alliance has spent the year extolling self-care, both mentally and physically. We have been exploring self-worth separate from our physician partners while strengthening the bond of the physician family. We have been uplifting and promoting our physicians and ourselves as leaders and team players, while recognizing the extreme kindness needed to encompass the entire person whose physical and mental health are at the crux of our world.

To this end, the Alliance gifted the MSMA members from Debbie Barbe, with Barbara Hover, our Vice Presidents of Health. It is a candle to put in the window, a symbol of a warm and welcoming home, a human signal of eager anticipation, of care and comfort.

## Commission on Continuing Education

The MSMA Commission on Continuing Education selected topics and speakers and peer-reviewed presentations for the 2025 Annual Convention General Sessions and approved the 2025 Annual Convention for 4.0 AMA PRA Category 1 Credits.

## Commission on Medical Economics, Third Party Medicine, and Government Relations

The Commission on Medical Economics, Third Party Medicine, and Government Relations met by videoconference on June 18, 2025, to discuss one resolution referred to us by Council. We entertained lively discussion on it, and offered the following recommendation for Council:

### *Resolution #15 – Addressing Misinformation in AI Used in Healthcare*

The Commission discussed this resolution intently. In the end, there was agreement that MSMA should be attentive to AI in healthcare, but certain parts of the resolution went beyond the resources of MSMA. The Commission decided to concentrate on identifying misinformation. In addition, the Commission believed language was needed giving physicians responsibility for AI-created communications and records.

Therefore, we recommend Council adopt the following substitute resolution:

RESOLVED, that our Missouri State Medical Association support efforts and accountability for decreasing misinformation in AI used in healthcare, and that physicians remain responsible for the accuracy of the content of communication and records.

In July, the MSMA Council adopted amended resolution:

RESOLVED, that the MSMA supports the use of AI in healthcare that is accurate and evidence based.

The Commission met by videoconference on October 30, 2025, to discuss two resolutions referred to it by the Council Chair, and made the following recommendations to Council:

### *Resolution #11 – Advancing Aging Medicine*

The Commission on Medical Economics recommends adopting a substitute resolution:

RESOLVED, that the MSMA support programs that support longevity healthcare, and enhance patient education, early detection, and treatment of age-related diseases. It was adopted.

### *Resolution #13 – Denial of Telephone Access by Emergency Physicians to Medical Center-based Specialists*

The Commission on Medical Economics recommends not adopting the resolution.

## Report of the Collective Bargaining Task Force

The MSMA Collective Bargaining Task Force met twice in 2025. Our first meeting was a videoconference with leading healthcare unionization attorney Richard Levenstein. The second was a videoconference with Mark Bonnano from the Oregon Medical Association. Oregon is one of the states leading the way on physician collective bargaining and employment issues.

The task force has met once so far in 2026, discussing collective bargaining with Nisha Gandhi, MD, an organizing physician in Delaware. We anticipate making a recommendation to MSMA Council at the July or October 2026 meeting.

## Report of the Healthcare Stabilization Task Force

The MSMA Healthcare Stabilization Task Force has met once so far in 2026 with several meetings planned for the remainder of the year. Our first meeting was introductory and dealt with housekeeping issues. We plan to invite various speakers to future meetings, including from states with well-established healthcare stabilization funds. We anticipate having a recommendation for the MSMA Council in early 2027.

## Report of the IMG Task Force

The MSMA IMG Task Force met on January 13 and March 8, 2026. The task force has identified two issues for further discussion and possible future action by the Council. IMG parity policy was passed by Council in July, and staff is currently working on implementation through the Board of Healing Arts. Additional pathways to licensure are a legislative issue, and the task force plans to have a recommendation for Council at the July or October 2026 meeting.

## Committee on Membership

The 2025 MSMA membership year closed with 1,600 active members (a 14% decrease from 2024), 560 residents, 1,504 students, and 262 retired members. Active membership has decreased 45% since the end of the 2014 dues year. A large increase in resident and student members of the same timeframe helps balance the numbers.

So far in the 2026 dues year, approximately 104 physicians have joined as new active members. On the other hand, 336 active members in 2024 have failed to renew. In addition to traditional recruiting methods, there was a positive response to MSMA phone calls to non-renewals. Peer-to-peer outreach is the most beneficial way to maintain and grow membership. Please ask MSMA staff for a list of non-members in your area and help us add physicians to the MSMA roster.

MSMA offered a "Summer Special" discounted membership rate in 2025 that attracted 40 new members. Over the past four summers, 252 physicians have joined at the discounted summer rate; at least 34 are now paying active dues.

MSMA staff was able to participate in several events across the state in 2025, including medical school recruitment events. In addition to our social media presence, MSMA hopes to attract more members through additional advocacy publications and events. We encourage all members to follow us on social media and share our posts. Please let MSMA staff know if you would like them to present to your local physicians.

## Missouri Physicians Health Foundation

For years, the MSMA Physician Health Foundation provided direction and oversight to the Missouri Physician Health Program (MPHP). After many years of service to the physicians of Missouri, MPHP terminated corporate affairs in 2025. The reasons for this are complex, but post-pandemic donations were not enough to allow MPHP to meet its expenses. After 18 months of attempting to right the ship, the Board was left with no choice other than to cease MPHP operations. All MPHP participants were successfully transferred to the MU Healthcare Professional Health

Program and the St. Louis Physician Health Program.

Despite the conclusion of the MPHP, the MSMA Physician Health Foundation continues to support physician mental health and wellbeing. We look forward to this new chapter for the Foundation.

## Missouri State Medical Foundation

The Missouri State Medical Foundation has made more than 3,000 medical school student loans over the past 53 years, totaling nearly $12 million. The loan program has been closed, and the Foundation now funds Missouri State Medical Association scholarships, which have been awarded over the past 19 years.

In 2025, the Foundation once again awarded $5,500 MSMA scholarships to a total of 60 medical students at the six Missouri medical schools. This totals $330,000 in scholarships.

In 2026, the Foundation will increase its scholarship giving to $6,000 for each of 60 medical students, for a total of $360,000. The Foundation has provided a cumulative total of $2.8 million scholarships awarded to second-year medical students who graduated from Missouri schools and are attending a medical school in Missouri.

The Foundation also matches funding up to $5,000 for local medical society scholarships. The MSMA Alliance has been an important partner to the Foundation through generous fund-raising activities, contributing more than $8,000 in 2025.

## Committee on Publication

Volume 122 of *Missouri Medicine* published original research, up to date scholarly reviews, and analysis of important individual and public health matters. This volume published five issues featuring "theme" articles (Precision Health, Aging, Physical Medicine and Rehabilitation, Pediatric Psychiatry, and Community and Family Medicine), and one issue presenting an informative variety of scientific topics and advocacy perspectives. It contained 532 pages and 47 scientific articles.

Perspectives included continued coverage of reimbursement of non-physician clinical services, private equity harm to healthcare, medical implications of artificial intelligence, fake science and distrust, Missouri's overdose data, physician shortages, carbon monoxide poisoning, and burnout/suicide among physicians. We published a retrospective analysis on COVID: Lessons Learned in 2025, authored by MSMA members David McKinsey, MD, and Joel P. McKinsey, Kansas City.

Medical-Legal articles covered medical practice and artificial intelligence, opioid prescribing responsibilities, and liability in virtual care.

*Missouri Medicine* continued a new series of Perspectives: Inspiring Lives & Careers, highlighting physicians around the state and how they are an inspiration to others. This generated much approval by the membership based on emails, texts and conversation.

*Missouri Medicine* would like to thank these invited peer-reviewers for their time and expertise this past year: John Vukich, MD, Vance Thompson, MD, Steve Slade, MD, Christian Rojas-Moreno, MD, Carissa van den Berk-Clark, PhD, Kenneth Haller, MD, Sarah S. Procknow, MD, Farrin Manian, MD, Carl V. Migliazzo, MD, Charles Lederer, MD, Brenda Rogers, MD and Catherine E. Hagan, PhD, DVM.

These are the updates to the *Missouri Medicine* Editorial Board: Nicholas N. Gier, MD, is a Hospitalist with Gates Hospitalists in Kansas City. He replaces Emily A. Hillman, MD, who completed her three-year term, and we thank her for a great job. Jerry Kennett, MD, and Joseph A. Corrado, MD, are leaving their positions in Cardiology and General Surgery, respectively. We thank both for their generous service to our Journal as well as MSMA, including serving as Presidents for our Association. Jeffrey Coughenour, MD, Medical Director, Frank L. Mitchell, Jr., MD, Professor of with University of Missouri-Columbia, is our next General Surgery Editorial Board Member. Vrinda Trivedi, MD, Assistant Professor of Medicine at the University Missouri-Columbia, is stepping up as our Cardiology Board Member.

Abid M. Bhat, MD, is the new Sleep Medicine Editorial Board Member. He is a Professor of Medicine in the Division of Pulmonary, Critical Care, and Sleep Medicine at University Health Hospital, University of Missouri – Kansas City School of Medicine. Julie M. Marshall, MD, FASA, is a Professor of Anesthesiology, Vice Chair for Education and Faculty Development, and Interim Director of Research in the Department of Anesthesiology, University of Missouri Health Care in Columbia, Missouri. She replaces Kathy Perryman, MD, who has served the Editorial Board since 2018. We thank Dr. Perryman for her service. Mark R. Wakefield, MD, University of Missouri Healthcare, is Director of the Renal Transplant Program, Division Chief of Urologic Surgery, and Professor of Surgery, is our new Urology board member. He replaces Elizabeth A. Piontek, MD, Saint Luke's Health System, Kansas City, Missouri, who has served the Editorial Board for almost a decade. We thank Dr. Piontek for her service. John B. Holds, MD, FACS, an internationally known oculo-plastic surgeon and world lecturer practicing in St. Louis, Missouri, has joined *Missouri Medicine*'s Contributing Editors and Committee on Publication Board. He has served as our Ophthalmology Editorial Board member for over a decade. Blake Cooper, MD, MPH, FACS, has joined the Editorial Board in Ophthalmology. Dr. Cooper is an ophthalmologist at Retina Associates in Kansas City, Missouri. He has also served as the President of Kansas City Society of Ophthalmology and on the Board of Directors of Missouri Society of Eye Physicians & Surgeons. He replaces John Holds, MD. David O. Barbe, MD. FAAP, joined the Editorial Board in the newly created position of Physician Advocacy. Dr. Barbe retired in 2025 from a 40-plus year career in Family Medicine. He now sees patients at MSU Care Clinic in Springfield, Missouri. Long active in local, state, national, and international organized medicine, he served as the Physician Executive for Mercy Southwest Missouri, President of the Missouri State Medical Association, President of the American Medical Association, and President of the World Medical Association. William 'Russ' Carpenter, DO, FASAM, joined Editorial Board in Physician Wellness, beginning in January 2026. Dr. Carpenter is a psychiatrist at the Center for Mental Wellness at Capital Region Medical Center in Jefferson City, Missouri, and the Director of the Missouri Physician and Health Professional Wellness Program (MOPHP). He replaces Stephen T. Keithahn, MD, who is retiring. We thank Dr. Keithahn for his expertise.

*Missouri Medicine* remains one of the country's foremost state medical journals. Thanks go to MSMA for 122 years of supporting its journal, Walsworth Publishing Company for over a century of printing and digital production, our highly qualified and experienced Contributing Editors, our specialty board experts, and the chairs and coordinators at Missouri's six outstanding medical schools on eight campuses.

The Committee on Publication Chair and Editor, John C. Hagan, III, MD, and Managing Editor, Lizabeth Fleenor, BJ, MA, appreciate the many contributions of the MSMA, its leadership, Alliance, and Active members and others. The Committee on Publication appreciates the Association's continued support of the Journal. By any objective criteria *Missouri Medicine* is among the top three state medical society journals in the United States. Our plan is to keep it that way.

## Committee on Public Affairs

The Commission on Public Health met by videoconference on October 30, 2025, to discuss one resolution referred to us by the Council Chair. We entertained lively discussion on it, and offered the following recommendation for Council, which was approved:

### *Resolution #8 – Hospital Internal Temperatures*

The Committee on Public Health recommends adopting substitute resolution:

RESOLVED, that the MSMA delegation to the AMA will support a resolution that establishes a standard for hospitals' common area internal temperature.

Following discussion, on motion, the Council voted to not adopt this resolution. **MM**

# Missouri State Medical Association

## *Statement of Financial Position*
## *December 31, 2025 and 2024*

**ASSETS**

| | 2025 | 2024 |
|---|---|---|
| **CURRENT ASSETS:** | | |
| Cash and Cash Equivalents | $ 578,436 | $ 873,407 |
| Certificates of Deposit | 269,096 | - |
| Current Investments | 14,715,754 | 13,241,265 |
| Interest Receivable | 34,192 | 31,955 |
| Accounts Receivable | 21,400 | - |
| Prepaid Expenses | 29,313 | 32,554 |
| Due from Affiliates | 3,922 | 635 |
| Total Current Assets | 15,652,113 | 14,179,816 |
| **FIXED ASSETS:** | | |
| Land | 83,000 | 83,000 |
| Construction in Progress | - | 350,514 |
| Building and Improvements | 1,283,864 | 604,391 |
| Furniture and Equipment | 28,721 | 26,643 |
| Less: Accumulated Depreciation | (612,072) | (607,386) |
| Total Net Fixed Assets | 783,513 | 457,162 |
| **OTHER ASSETS:** | | |
| Pension Benefit Asset | 437,340 | 802,332 |
| Note Receivable - MSMA Ins. Agency | - | 154,700 |
| Due from MSMA Ins. Agency | - | 95,300 |
| Investment in Subsidiary - MSMA Ins. Agency | - | 5,609 |
| Investment in Association Health Plan | - | 9,000 |
| Non-Current Investments | 3,986,805 | 3,731,953 |
| Total Other Assets | 4,424,145 | 4,798,894 |
| **TOTAL ASSETS** | $ 20,859,771 | $ 19,435,872 |

**LIABILITIES AND NET ASSETS**

| | 2025 | 2024 |
|---|---|---|
| **CURRENT LIABILITIES:** | | |
| Accounts Payable and Accrued Expenses | $ 23,515 | $ 30,218 |
| Accrued Vacation | 34,057 | 56,101 |
| Payroll Liabilites | 36,361 | 11,044 |
| Income Taxes Payable | 7,006 | 3,216 |
| Funds Held for Others | 71,101 | 71,581 |
| Contract Liabilities - Subscriptions, Fees and Conference Income Received in Advance | 500 | 60,000 |
| Contract Liabilities - Dues Received in Advance | 459,575 | 519,825 |
| Total Current Liabilities | 632,115 | 751,985 |
| **NON-CURRENT LIABILITIES:** | | |
| Deferred Compensation Agreement | 312,282 | 244,838 |
| Pension Benefit Liability | 437,340 | - |
| Total Non-Current Liabilities | 749,622 | 244,838 |
| Total Liabilities | 1,381,737 | 996,823 |
| **NET ASSETS:** | | |
| Without Donor Restrictions | 19,478,034 | 18,442,494 |
| Total Net Assets | 19,478,034 | 18,442,494 |
| **TOTAL LIABILITIES AND NET ASSETS** | $ 20,859,771 | $ 19,439,317 |

# Missouri State Medical Foundation

## *Statement of Financial Position*
## *December 31, 2025*

**ASSETS**

| | 2025 |
|---|---|
| **CURRENT ASSETS:** | |
| Cash | $ 300,281 |
| Investments | 6,273,105 |
| Notes Receivable - Current | 42,388 |
| Accrued Interest | 23,607 |
| Total Current Assets | 6,639,381 |
| **EQUIPMENT:** | |
| Software | 10,692 |
| Less: Accumulated Depreciation | (10,692) |
| Total Net Fixed Assets | - |
| **NON-CURRENT ASSETS:** | |
| Investments | 1,567,104 |
| Notes Receivable - Long Term | 231,071 |
| Allowance for Credit Losses | (41,019) |
| Notes Receivable - Long Term (Net) | 190,052 |
| Total Non-Current Assets | 1,757,156 |
| **TOTAL ASSETS** | $ 8,396,538 |

**LIABILITIES AND NET ASSETS**

| | |
|---|---|
| **LIABILITIES:** | |
| Excise Tax Payable | $ 6,815 |
| Funds Held for Others | 177,919 |
| **TOTAL LIABILITIES** | 184,734 |
| **NET ASSETS:** | |
| Without Donor Restriction | 8,211,804 |
| **TOTAL LIABILITIES AND NET ASSETS** | $ 8,396,538 |

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# 2026 Annual Convention Attendance

| | |
|---|---|
| ***Members*** | ***47*** |
| ***Staff*** | ***7*** |
| ***Guests*** | ***46*** |
| ***Officers*** | ***8*** |
| ***Councilors/Vice*** | ***22*** |
| ***Alliance*** | ***18*** |
| ***Total*** | ***148*** |

***(Actual numbers will not balance due to overlaps in positions served.)***

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