I
n this issue of ANESTHESIOLOGY, Mashour et al. present an
extensive analysis of the prospectively collected American
College of Surgeons National Surgical Quality Improvement
Program (ACS-NSQIP) database. The authors investigated
perioperative stroke in patients undergoing noncardiac nonneu-
rologic surgery. They analyzed more than 523,000 patients in
the NSQIP database and developed a risk model to predict the
occurrence of ischemic and hemorrhagic stroke. The model was
derived from a cohort of approximately 350,000 patients and
validated in a 173,000-patient cohort. The overall incidence of
stroke in both cohorts was 0.1%. Perioperative stroke increased
30-day mortality by 8-fold (21% absolute risk increase of mor-
tality in a comorbidity matched cohort).

Multivariate logistic regression revealed nine predictors of
stroke and one protective factor. These 10 elements were used
to create a risk model. The risk factors for stroke included: age 62
yr or older, myocardial infarction within 6 months of surgery,
hypertension, history of stroke, history of transient ischemic
attack, history of chronic obstructive pulmonary disease, dialy-
sis, acute renal failure, and current tobacco use. Surprisingly,
moderate obesity was protective (body mass index 35–40).
There were no data regarding atrial fibrillation, other dysrhyth-
mias, or hypotension in the NSQIP database, so these values
could not be included. In the final unweighted model, stroke
risk was 0.1% in patients with two or fewer risk factors, 0.7% in
those with three or four risk factors, and 1.9% in the highest risk
group with five or more risk factors. Despite the author’s pref-
erence for a “simpler” unweighted risk classification, a weighted
risk score would have been more precise, as the risk associated
with the identified predictors varies considerably (hazard ratio
range: 0.6–3.9).

How do we use these data? Even in the highest risk group
identified by Mashour et al., perioperative stroke was an uncom-
mon adverse event (occurring in 1 in 50 patients) after noncar-
diac nonneurologic surgery. In fact, this high-risk population is
elderly and sick and at risk for any of a large number of uncom-
mon adverse events. The addition of atrial fibrillation to the risk
assessment, if the data were available, would likely add predic-
tive power but still not change the perioperative management of
the individual patient. After all, any medically indicated antico-
agulant and antiplatelet therapy should be restarted as soon as
safely possible after surgery. Intraoperative hypotension should
be treated aggressively. Thus, the anesthesiologist and surgeon
are left with few practical options for preventing perioperative
stroke beyond providing high-quality routine care.

So where do we go from here? Perioperative stroke is an
uncommon complication with devastating consequences,
as detailed by Mashour et al. Stroke is also a heterogeneous
disease resulting from a multitude of etiologies. Periopera-
tive ischemic stroke can be caused by cardioembolism
(from dysrhythmia or valvular disease), paradoxical embol-
ism through a right to left cardiopulmonary shunt, artery-to-artery embolism, in situ thrombus formation in atherosclerotic cerebral vessels, or distal arterial watershed
infarction from hypoperfusion. Venous infarction (ischemic or hemorrhagic) caused by cerebral sinus or cortical vein thrombosis can occur perioperatively in patients with
hypercoagulability. Perioperative hemorrhagic stroke may
be caused by hypertension or hemorrhagic transformation
of an ischemic infarct, possibly exacerbated by antiplatelet
or anticoagulant therapy. Finally, other neurologic out-
comes such as cognitive dysfunction may be on a contin-
um with perioperative stroke, but there is insufficient
evidence at this time to go beyond mere speculation.

Once again, where do we go from here? How do we prevent
this serious uncommon complication that is multifactorial in
etiology?

Better Data. First and foremost, this is a call for better pro-
spective data gathering. The work of Mashour et al. illus-
trates the limitations of the NSQIP database, despite the
laborous efforts of very dedicated nurses across the United
States. Understanding uncommon events such as periopera-
tive stroke will require detailed information on the entire
spectrum of care from all surgical patients. The Centers for
Medicare and Medicaid Services have mandated that elec-
tronic medical records meet meaningful use criteria and are
providing financial incentives toward this end. This en-
deavor is currently accelerating the adoption of electronic
medical records.* Although universal integration of various
healthcare databases is likely decades away in the United

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* Dolan PL. American Medical News. EMR adoption rates up,
with small practices left behind. Available at: http://www.ama-assn.

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et al. Perioperative stroke and associated mortality after noncardiac,
States, large health systems should be able to accomplish this within the next 5 yr. Direct note entry by physicians, midlevel providers, and nurses into queryable informatics systems will allow researchers to create much higher level analyses. The NSQIP stroke patients undoubtedly saw a neurologist and underwent imaging studies, cardiac assessments, rhythm monitoring, and review of intraoperative hemodynamic variables and were on various regimens of antiplatelet, anticoagulant, antihypertensive, and statin therapies. However, none of these data are routinely obtainable for research. This information would have likely created a very different predictive model and conclusions regarding at risk populations.

With better risk assessments, patients at high risk of perioperative stroke (more than 10%, for example) could be studied prospectively in reasonably sized yet adequately powered trials investigating new preventive interventions. Statins, antiplatelet and anticoagulant regimens, and antiinflammatory and novel neuroprotectant therapies could be pursued. Intraoperative neuromonitoring, such as with cerebral oximetry, might show benefit in patients at high risk of stroke. Modest hypertension may be beneficial intraoperatively. The Perioperative Ischemic Evaluation Study Trial demonstrated an increase in stroke with indiscriminant β-blockade. However, in that study, only 60 strokes occurred in the more than 8,300 patients at risk for atherosclerotic disease. This finding highlights the need to identify an even higher risk cohort for inclusion in future trials to achieve the necessary event rates.

Genomic, proteomic, and metabolomic studies hold great promise for identifying high-risk individuals and diagnosing acute stroke. However, this field is still in its infancy despite more than a decade of research. Connecting genotype to phenotype depends on large cohorts of patients with well-defined stroke syndromes. Known modifiable risk factors, such as diabetes and hypertension, only explain approximately two thirds of the risk for stroke. Genetic mechanisms of stroke are known only for a few rare stroke syndromes such as cerebral autosomal dominant arteriopathy with subcortical infarcts and dementia, commonly known by the acronym CADASIL. Genetic polymorphisms causing hypercoagulability, such as factor V Leiden, increase the risk for cerebral sinus thrombosis and deep venous thrombosis, but account for a small number of perioperative strokes. We are still a long way from understanding the genomics and proteomics of common stroke syndromes.

**What About Now?** For the time being, physicians need to maintain vigilance for perioperative stroke. Neurologic function can be assessed at the bedside on routine examination, even by simply observing the patient’s movements, speech, and cognition during a brief postoperative visit. Neurologic signs or symptoms should trigger stroke codes and stroke teams that can emergently triage patients for acute interventions such as thrombolysis (intravenous or intraarterial) and/or endovascular clot removal. Immediate treatment is paramount as outcomes worsen with time from ictus; “time is brain.”

We must continue to search for answers to stroke and neurocognitive complications in the perioperative period. Our current databases are largely insufficient, and new approaches are needed. We applaud the determination of investigators, such as Dr. Mashour, to see this work move forward. Robert Frost published “Stopping by Woods on a Snowy Evening” in 1923. That same year he was a visiting fellow in Ann Arbor, not far from University of Michigan Hospital where Mashour et al. currently practice. So it seems fitting to remind the anesthesiology community now, nearly a century later, that we have “promises to keep, and miles to go before (we) sleep.”

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**References**


