Neurological Complications of Cardiac Disease and Cardiac Surgery

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Disclosures

• None
Learning Objectives

• Understand the role of AF in the risk of ischemic stroke

• Recognize the main neurological complications of infective endocarditis

• Discuss the risk of cerebrovascular events and cognitive decline after cardiac revascularization

• Evaluate the risk of ICH in patients treated with LVAD or ECMO
Outline

• Embolic stroke
• Infective Endocarditis
• Coronary revascularization
• LVAD
• ECMO
• Cardiac Arrest
Cardioembolic Stroke

• One of the most common mechanisms of ischemic stroke and probably the most common in the elderly

• Main risk factor: Atrial Fibrillation (or flutter, persistent or paroxysmal)

• Other risk factors:
  Mechanical valves (mitral > aortic)
  Infective or marantic endocarditis
  Severe left ventricular dysfunction (mural thrombi, apical aneurysms)
  Atrial myxoma
Up to 12 million by 2050 just in the US

If incidence continues to increase

If incidence stable

Heart Dis and Stroke Stats – AHA
Prolonged Cardiac Monitoring for Detection of Paroxysmal Atrial Fibrillation After Cerebral Ischemia

Alejandro A. Rabinstein, MD

Table 1. Main Characteristics of Available Methods for Prolonged Ambulatory Cardiac Rhythm Monitoring

<table>
<thead>
<tr>
<th>Device</th>
<th>Location</th>
<th>Duration</th>
<th>Minimal Threshold</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holter</td>
<td>Skin surface</td>
<td>Usually 1–2 d</td>
<td>Few seconds</td>
<td>Short duration</td>
</tr>
<tr>
<td>External loop recorder</td>
<td>Skin surface</td>
<td>≤30 d</td>
<td>Few seconds</td>
<td>Requires patient action</td>
</tr>
<tr>
<td>Ambulatory telemetry</td>
<td>Skin surface</td>
<td>≤30 d</td>
<td>Few seconds</td>
<td>Patient compliance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Skin irritation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cost</td>
</tr>
<tr>
<td>Implantable loop recorder</td>
<td>Subcutaneous</td>
<td>≤3 y</td>
<td>2 min</td>
<td>Invasiveness (minimal)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Does not detect PAF&lt;2 min</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cost</td>
</tr>
<tr>
<td>Dual-chamber pacemaker and defibrillator</td>
<td>Intracardiac</td>
<td>Many years</td>
<td>Seconds</td>
<td>Only indicated for life-threatening arrhythmias</td>
</tr>
</tbody>
</table>
Diagnostic yield by phases

- ECG on admission: 7.7%
- In-hospital serial/continuous ECG: 5.1%
- Ambulatory Holter: 10.7%
- Prolonged ambulatory monitoring: 16.9%

- Overall diagnostic yield: 23.7%

- When including 20% of patients with known AF before the stroke/TIA → a total of 39% of stroke pts can be estimated to have AF

Lancet Neurol 2015;14:377-87
An artificial intelligence-enabled ECG algorithm for the identification of patients with atrial fibrillation during sinus rhythm: a retrospective analysis of outcome prediction

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Summary

Background Atrial fibrillation is frequently asymptomatic and thus underdetected but is associated with stroke, heart failure, and death. Existing screening methods require prolonged monitoring and are limited by cost and low yield. We aimed to develop a rapid, inexpensive, point-of-care means of identifying patients with atrial fibrillation using machine learning.

Methods We developed an artificial intelligence (AI)-enabled electrocardiograph (ECG) using a convolutional neural network to detect the electrocardiographic signature of atrial fibrillation present during normal sinus rhythm using standard 10-second, 12-lead ECGs. We included all patients aged 18 years or older with at least one digital, normal sinus rhythm, standard 10-second, 12-lead ECG acquired in the supine position at the Mayo Clinic ECG laboratory between Dec 31, 1993, and July 21, 2017, with rhythm labels validated by trained personnel under cardiologist supervision. We classified patients with at least one ECG with a rhythm of atrial fibrillation or atrial flutter as positive for atrial fibrillation. We allocated ECGs to the training, internal validation, and testing datasets in a 7:1:2 ratio. We calculated the area under the curve (AUC) of the receiver operating characteristic curve for the internal validation dataset to select a probability threshold, which we applied to the testing dataset. We evaluated model performance on the testing dataset by calculating the AUC and the accuracy, sensitivity, specificity, and F1 score with two-sided 95% CIs.

Findings We included 180 922 patients with 649 931 normal sinus rhythm ECGs for analysis: 454 789 ECGs recorded from 126 526 patients in the training dataset, 64 340 ECGs from 18 116 patients in the internal validation dataset, and 130 802 ECGs from 36 280 patients in the testing dataset. 3051 (8.4%) patients in the testing dataset had verified atrial fibrillation before the normal sinus rhythm ECG tested by the model. A single AI-enabled ECG identified atrial fibrillation with an AUC of 0.87 (95% CI 0.86–0.88), sensitivity of 79.0% (77.5–80.4), specificity of 79.5% (79.0–79.9), F1 score of 39.2% (38.1–40.3), and overall accuracy of 79.4% (79.0–79.9). Including all ECGs acquired during the first month of each patient’s window of interest (ie, the study start date or 31 days before the first recorded atrial fibrillation ECG) increased the AUC to 0.90 (0.89–0.91), sensitivity to 82.3% (80.9–83.6), specificity to 83.4% (83.0–83.8), F1 score to 45.4% (44.2–46.5), and overall accuracy to 83.3% (83.0–83.7).

Interpretation An AI-enabled ECG acquired during normal sinus rhythm permits identification at point of care of individuals with atrial fibrillation.
AF and Stroke: How are they related?

**Implications**
- **AF should precede** CVA
- Control of AF may prevent CVA
- LAA closure prevents CVA

**Implications**
- AF burden predicts risk
- No temporal association between AF and stroke
- Role of LAA depends on which tissue affected
Stroke Prevention in AF

• **Chronic Anticoagulation**
  - DOACs have half the risk of ICH compared with warfarin
  - Aspirin does not really work

• **Left Atrial Appendage Occlusion**
  - Reserved for patients who cannot tolerate chronic anticoagulation
Infective Endocarditis

• Focal or diffuse neurological complications:
  - Cerebrovascular embolism
  - Intracranial Hemorrhage
  - Microbleeds
  - Encephalopathy
  - Seizures
  - Brain abscess/meningitis
  - Visual changes
Ischemic Stroke in IE

- Incidence 6-31%
- Presenting feature in 14% (75% of embolic strokes occur at presentation)
- Brain emboli in autopsy: 50-60%
- Risk greater with virulent organisms
- Recurrence very low after full course of antibiotics with good response
Intracranial Hemorrhage in IE

- ICH, SAH, hemorrhagic conversion
- **Septic arteritis** → mycotic aneurysms
- Risk factors: Anticoagulation
  - Staph aureus
  - IVDA
  - Large infarcts
  - Delay in starting ATB
Prevention and Treatment

- Prompt antibiotics
- Valve surgery when indicated
- Avoid anticoagulants
- Treat mycotic aneurysms
Variable Significance of Brain MRI Findings in Infective Endocarditis and Its Effect on Surgical Decisions

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Abstract

Objective: To determine how brain magnetic resonance imaging (MRI) findings impact clinical outcomes in patients with infective endocarditis (IE) and to propose a management algorithm for patients with neurologic symptoms who are candidates for valve surgery (VS).

Patients and Methods: Data from our center were retrospectively reviewed for patients hospitalized with IE between January 1, 2007, and December 31, 2014. Outcomes were postoperative intracerebral hemorrhage (ICH), 6-month mortality, and functional outcome at last follow-up as described by the modified Rankin Scale (mRS) score. Good outcome was defined as an mRS score of 2 or less.

Results: A total of 361 patients with IE were identified, including 127 patients (35%) who had MRI. One hundred twenty-six of 361 patients (35%) had neurologic symptoms, which prompted MRI in 79 of 127 patients (62%); 74 of 79 (94%) had acute or subacute MRI abnormalities. One patient with subarachnoid and multifocal ICH on MRI developed postoperative ICH. Patients with VS despite MRI abnormalities had lower 6-month mortality (odds ratio [OR], 0.17; 95% CI, 0.06-0.48; P<.001) and better functional outcome (OR, 4.43; 95% CI, 1.51-13.00; P=.005). Irrespective of VS, lobar or posterior fossa ICH on MRI was associated with 6-month mortality (OR, 3.58; 95% CI, 1.22-10.50; P=.02) and territorial ischemic stroke was inversely associated with good mRS (OR, 0.29; 95% CI, 0.13-0.66; P=.002). In neurologically asymptomatic patients who had VS, MRI findings did not impact 6-month mortality or functional outcomes.

Conclusion: Magnetic resonance imaging detects a large number of abnormalities in patients with IE. Preoperative lobar hematoma and large territorial stroke determine outcome irrespective of VS. When indicated, VS increases the odds of a good outcome despite MRI abnormalities.
Coronary Revascularization

• Stroke is an uncommon but severe complication of coronary revascularization

• Main risk factors are older age and previous stroke

• Risk is lower with PCI (0.2% to 0.4%) than with CABG (1% to 3%)

• Silent infarctions much more common

• Most strokes are thromboembolic
The Safety and Efficacy of Thrombolysis for Strokes After Cardiac Catheterization

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Cincinnati, Ohio; Minneapolis, Minnesota; Florence, Italy; Chennai, India; Bronx, New York; Charleston, South Carolina; Washington, DC; and Philadelphia, Pennsylvania

Objectives

The purpose of this study was to systematically compare clinical outcomes of patients treated with thrombolysis with those without treatment in a multi-year, multicenter cohort of strokes after cardiac catheterization.

Background

Ischemic strokes after cardiac catheterization procedures, although uncommon, lead to the morbidity and mortality of thousands of patients each year. Despite the availability of Food and Drug Administration-approved thrombolytic therapy for acute ischemic stroke since 1996, thrombolysis remains unestablished in the setting of cardiac catheterization, owing to unique concerns regarding safety and efficacy.

Methods

Consecutive cases of ischemic stroke after cardiac catheterization were abstracted retrospectively and reviewed by clinicians at 7 major North American academic centers with acute stroke teams. Safety and efficacy outcome measures were pre-defined.

Results

A total of 66 cases of ischemic strokes after cardiac catheterization were identified over 3 to 4 years; 12 (18%) were treated with thrombolysis, consisting of 7 intravenous and 5 intra-arterial recombinant tissue plasminogen activator cases. Improvement in stroke symptoms, as measured by the primary efficacy measure of median change in National Institutes of Health Stroke Scale score from baseline to 24 h, was greater in treated versus nontreated cases (p < 0.001). Additional secondary measures of efficacy also showed better outcomes in the treated group. There were no significant differences in bleeding events, defined as symptomatic intracerebral hemorrhage, hemopericardium, or other systemic bleeding resulting in hemodynamic instability or blood transfusions. Mortality rates were also similar.

Conclusions

Thrombolysis might improve early outcomes after post-catheterization strokes and seems safe in this context. Emergent cerebral revascularization should be a routine consideration. (J Am Coll Cardiol 2008;51:906–11)

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Challenges of managing post-CABG stroke

- Delayed recognition
- High, if not prohibitive risk of IV lysis
- Patients may be less stable to undergo endovascular intervention
- Stroke is not always caused by thromboembolism
Silent cerebral infarctions

- Clinically apparent: 0.2–0.4% - Neurological examination
- Subclinical - Neuropsychological testing
- Subtle cerebral infarct (5–23%) - Cerebral imaging
- Subtle cerebral injury (100%) - Biological markers?

Nat Rev Cardiol 2013;10:696-706
Cognitive decline after CABG

• A recent meta-analysis concluded that there is little if any evidence of persistent cognitive decline after CABG

• However, there is still insufficient information on whether some patients may be at higher risk

• No interventions (off-pump, hypothermia, minimal vs conventional extracorporeal bypass) proved beneficial in reducing the risk of persistent cognitive decline
Cognition after CABG: goes but comes back

Neurosci Behav Rev 2012
LVAD

- **Intracranial hemorrhage**
  (intracerebral > subarachnoid > subdural)

- **Ischemic infarction**

- **Seizures**

- **Cerebral hypoperfusion**

- **Cognitive impairment**
**Table 1. Summary of risk factors for neurologic complications in patients with CF-LVAD.**

<table>
<thead>
<tr>
<th>Preoperative risk factors</th>
<th>Intraoperative risk factors</th>
<th>Postoperative risk factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female gender</td>
<td>Surgical closure of the aortic valve</td>
<td>No aspirin 7 days prior to event</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>Cross-clamping the aorta with cardioplegic arrest</td>
<td>INR &lt;2 or INR &gt;3</td>
</tr>
<tr>
<td>Prior stroke</td>
<td>Inflow and outflow graft angles</td>
<td>Driveline/pump infection</td>
</tr>
<tr>
<td>Hypertension (SBP &gt;140 or DBP &gt;90)</td>
<td>Pulsatile flow device &gt;Continuous flow device</td>
<td>Hypertension (MAP &gt;90 mmHg)</td>
</tr>
<tr>
<td>Tobacco use</td>
<td>HeartWare &gt;HeartMate II &gt;HeartMate 3</td>
<td>Bacteremia</td>
</tr>
<tr>
<td>Malnutrition</td>
<td>Concurrent valve repair or CABG</td>
<td>UTI</td>
</tr>
<tr>
<td>Hyponatremia</td>
<td>Cardiopulmonary bypass time</td>
<td>Pump thrombosis</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td></td>
<td>Venous thromboembolism</td>
</tr>
</tbody>
</table>

Hypoalbuminemia
Pump speed <9000 RPM
<table>
<thead>
<tr>
<th>Device</th>
<th>6 Months</th>
<th>12 months</th>
<th>24 Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>HeartWare (C)</td>
<td>13.3%</td>
<td>16.9%</td>
<td>31.1%</td>
</tr>
<tr>
<td>HeartMate II (A)</td>
<td>10.1%</td>
<td>14.6%</td>
<td>15–19.2%</td>
</tr>
<tr>
<td>HeartMate 3 (C)</td>
<td>5.4–7.9%</td>
<td>9.4%</td>
<td>10.1%</td>
</tr>
</tbody>
</table>

C: centrifugal-flow device; A: axial-flow device.

*Expert Rev Cardiovasc Ther. 2018;16:909-917*
CV events with LVAD

- Mortality rate much higher after ICH than after ischemic stroke
- Highest with early ICH
- Major drop in chances of getting heart transplant
- Optimal timing of reinitiation of anticoagulation after large infarction or ICH remains unclear
ECMO

- Intracranial hemorrhage
- Ischemic infarction
- Seizures
- Cerebral hypoperofusion
- Encephalopathy
- Cognitive impairment
- Brain death
ECMO

• Rates of neurological complication are highly variable (15-50%) depending on definitions, age of patients, type of ECMO and indications

• Ischemic stroke or ICH: 5-10% (risk greatest in the first week)

• Brain complications are leading causes of mortality (especially ICH has 74% mortality rate)

• Possible risk factors for ICH: VA ECMO, greater fluctuations in CO2 upon connection, low platelet count, sepsis, hemolysis, renal failure
Key Messages

• AF and atrial cardiopathy are a major and growing risk factor for stroke

• Infective endocarditis primarily causes a septic arteritis

• PCI and CABG still have a 0.2-3% risk of clinical stroke and risk of higher in older patients with previous stroke

• ICH is a major cause of death in patients treated with LVAD or ECMO
FOLLOW YOUR HEART BUT TAKE YOUR BRAIN WITH YOU
Thank You