Stroke is the third-leading cause of death and the leading cause of disability in the United States. The risk factors for stroke are strikingly similar to those for coronary disease, so patients undergoing cardiac interventions for coronary disease have a periprocedural risk for stroke. Though the overall complication rates for cardiac catheterization and percutaneous coronary intervention (PCI) are low, periprocedural stroke affects thousands of patients each year. Stroke during and after diagnostic cardiac catheterization ranges from 0.11% to 0.4%; stroke during or after PCI ranges from 0.18-0.44%. Incidence of cerebral hemorrhage specifically after PCI is 0.2-0.3%. These statistics give insight into the fact that, though rare, stroke does occur in the Cardiac Cath Lab (CCL), necessitating the need for the staff to be cognizant of the signs and symptoms, along with the immediate actions to take in order to prevent suboptimal outcomes.

Patients who experience a stroke during or after diagnostic cardiac catheterization or PCI have an increased length of hospital stay by approximately four days, and experience moderate to severe disability post-discharge. The in-hospital mortality rate ranges from 25-44%. Rapid recognition of a stroke and immediate intervention can significantly improve the long-term outcomes. Therefore, identifying patients at high risk and being knowledgeable of the symptoms and treatment possibilities are vital. Corazon believes that raising the level of awareness of the CCL staff, and having clear protocols in place to address recognition and intervention regarding stroke can facilitate staff comfort and efficiency in the unlikely event of a stroke in the CCL.

**Stroke Risk Factors**

While the risk factors for cardiovascular disease and cerebrovascular disease are similar, invasive cardiac procedures carry additional inherent risks, which means the cath lab team must be aware of hospital protocol should a PCI patient suffer a stroke during or after their procedure. Patients at higher periprocedural risk for stroke are those with advanced age, female gender, history of stroke, renal failure, diabetes mellitus, arterial hypertension, peripheral vascular disease, dyslipidemia, tobacco use, atrial fibrillation, previous myocardial infarction, congestive heart failure, left-sided valvular disease, poor left ventricular systolic function, prior coronary artery bypass graft, and no or irregular use of needed antiplatelet medications. PCI done under emergent conditions and the use of an intra-aortic balloon pump also enhances the risk of stroke. Often, Corazon advocates education for cath lab staff on these and other possible risk factors. Such education can facilitate the staff’s early identification of those patients who are at high risk for a stroke and therefore increase their familiarity with taking appropriate actions to help prevent/minimize the possibility of any adverse events.

**Stroke Symptoms**

Stroke symptoms vary with the location of the infarct or hemorrhage. In the general population, 80-90% of emboli result in a stroke that affects the anterior cerebral circulation. In the cardiac catheterization population, however, greater than 50% of the emboli affect the vertebrobasilar circulation. Approximately 20% of the cerebral blood flow traverses the posterior circulation and even very small emboli in the can cause significant neuro deficits. Symptoms of vertebrobasilar circulation disruption include facial paresthesias, dysphagia, dysarthria, hoarseness, hemisensory extremity symptoms, motor weakness, diplopia, and sudden sensorineural hearing loss.

Common neurological deficits noted in general during stroke in the cath lab are motor weakness, aphasia, changes in mental status, visual disturbances with the most common being motor or speech deficits. Stroke symptoms can be camouflaged by or mimic the effects of sedation, making it more difficult to identify the occurrence of a stroke. Also, certain other conditions such as seizures, hypoglycemia, and migraine can mimic stroke symptoms.

Periodic reviews, placement of a poster, and/or competency assessment will aid in staff awareness and accurate diagnosis of the signs and symptoms of stroke. The neuro exam in the CCL should be focused on assessing for these particular signs and symptoms. Rapid discovery of a stroke and prompt intervention may minimize any long-term effects of the stroke or even save the life of the patient.

**Sources of infarcts**

Infarcts during catheterization and intervention arise from various embolic sources. The composition of the emboli also varies, from air to soft clot to calcified atheroma or multiple compositions such as atheroma with a fibrin clot around it.

Air emboli may result from large injections of air into the circulation down to gaseous microemboli that are due to microbubbles injected with contrast or saline. Transcranial Doppler (TCD) studies have shown multiple cerebral microemboli released during cardiac catheterization. The exact incidence of air emboli is unknown and there are no specific neurological signs or symptoms related to air embolism.

PICI involves the use of a larger guide catheter and more and stiffer caliber catheters than diagnostic catheterizations. This raises the risk of trauma to the aorta and the dislodgement of aortic atheroma during catheter manipulation. Thrombus formed within the catheter or catheter tip during the procedure can also become a source of emboli. There is a question regarding the relevance of upper extremity versus lower extremity access sites and the risk of aortic atheroma. The transradial approach to catheterization is thought to lead to a higher number of solid emboli due to mechanical forces near the apertures of the right vertebral and common carotid arteries; plaques in those areas risk becoming dislodged and embolizing to the brain.
The statistics quoted for periprocedural stroke do not reflect “silent” ischemic events (i.e., asymptomatic infarcts). Deficits may be non-existent or not readily noticeable, for example, some mild cognitive deficits. Since patients are not tested for these deficits, the impact on quality of life is uncertain, as are the long-term effects. It is estimated that asymptomatic cerebral infarction after cardiac catheterization has an incidence of approximately 15%. 6,11

Recognition of the source and type of infarct will aid in determining which type of immediate intervention will be most beneficial for the patient and in formulating overall acute care treatment and secondary stroke prevention plans.

Response to Stroke

Since the brain has minimal oxygen reserves, it cannot withstand an ischemic situation for any length of time without leading to permanent deficits. Therefore, it is imperative that interventions are instituted as soon as possible after stroke symptoms become evident. For a patient with stroke symptoms entering into the Emergency Department, treatment should be initiated within 60 minutes of entrance into the ED. In the case of the CCL, treatment should be initiated within 60 minutes of symptom discovery.

Unfortunately, there are at present no established protocols for addressing a stroke specifically in the CCL. Due to the lack of established clinical or operational standards, and the lack of data to be used for benchmarking against best-practice programs, internal measures are necessary to ensure optimal care for these high-risk patients.

Corazon recommends that the CCL set up a stroke alert process that would ensure a rapid response to a necessary stroke intervention within the cath lab setting. Issues that should be addressed include:

- Who should respond to the stroke code, (neurologist, neurological interventionalist, pharmacist, etc.)
- Who activates the alert process to notify the responders
- The roles of the individual CCL team members
- Actions to be taken and in what sequence

Based on Corazon experience with diverse programs across the country, typically, the personnel to notify during a stroke alert activation are:

- CT technician—to ensure availability of the scanner. Protocol usually dictates that the technician will finish the current patient and then hold the scanner open.
- Laboratory—as soon as the specimen is brought to the lab, the specimen will be run through the next batch of blood work and the results reported as soon as possible.
- Neurologist—to verify the instance of stroke and to help develop an optimal and timely treatment plan.
- Pharmacy—to verify dosage of weight-based t-PA and to mix necessary drugs and deliver them to the CCL.
- ICU—because the patient will require ICU bed if t-PA is administered or a mechanical intervention is performed.

Once the symptoms are evident, the stroke team responders should be notified and the patient assessed more critically for deficits. Assessment includes vital signs and basic neuro exam at least every 15 minutes, and performing the National Institutes of Health Stroke Scale (NIHSS). (See figure 1.) The NIHSS is critical in determining baseline deficits and in helping to determine the patient’s candidacy for thrombolytic intervention. The symptoms must be confirmed as a result from stroke, rather than other possible neurological events. Confirmation can be made via CT or MRI, though CT is usually the diagnostic test most readily available. The procedure catheter can remain in place for the CT if there is a potential to use it for an intra-arterial lytic intervention. Also, if the sheath is still in place, a cerebral angiogram can be performed in lieu of the CT scan. An angiogram will better determine thrombus morphology, the location and degree of the occlusion, and the status of collateral circulation than CT. 6 Also, the sheath can provide access for mechanical retrieval of the occluding material if necessary.

Selective intra-arterial treatment may be preferred if the patient has recently received antplatelets and anticoagulants which would increase the risk of bleeding. Since there is a lesser dose of drug administered, the risk of bleeding should be decreased. 3

Once the stroke is determined via CT and an infarct differentiated from a hemorrhage, a consulting neurologist can help weigh the benefits/risks ratio and develop a treatment plan. A neuro interventionalist can perform the angiogram or the intravascular interventions if necessary. If the CT suggests an infarct, the t-PA inclusion/exclusion criteria list should be reviewed. (See figure 2.) If the patient meets the criteria for intravenous t-PA, the drug should be started immediately.

t-PA dosage is weight-based at 0.9 mg/kg to a maximum of 90 mg. The drug is mixed in sterile water and should not be shaken or sent through a pneumatic, which would destroy some of the product. It is given in two stages: 10% of the total dose is given through a dedicated IV line over one minute, with the remaining 90% of the dose given over 60 minutes via IV infusion pump.

Vital signs and neuro exams are performed every 15 minutes for two hours, every half hour for six hours, then every hour for the next 16 hours. The patient should be admitted to an ICU for close monitoring for neurological changes and complications due to the t-PA. Intra-arterial t-PA will be administered at a lesser dose, which will be determined by the interventionalist. If the patient is not a candidate for either intravenous or intra-arterial t-PA, mechanical extravasation of the embolus or multimodal endovascular therapy may be considered. 13

Complications with t-PA administration occur in <5% of the patients receiving the drug. 6 Two critical complications that can occur with t-PA are intracranial or systemic bleeding and angioedema, both of which require immediate intervention. During or shortly after cardiac catheterization, retroperitoneal bleeding and groin hematoma can also occur. If the sheath is in place during lysis, leaving it there for several hours after t-PA infusion helps to minimize the risk of bleeding. The risk of retroperitoneal blood loss from compressible access site is lower with intra-arterial than intravenous t-PA.

If the stroke is due to an intracranial hemorrhage, anticoagulation should be reversed and a neurosurgeon consulted to determine if any surgical intervention is indicated. If the cerebral embolism is due to air, 100% oxygen should be administered by face mask and the patient considered for hyperbaric oxygen therapy. 7,9

In Conclusion

Stroke is an uncommon but potentially devastating complication of cardiac catheterization. Pre-procedure identification of the high-risk patient, along with measures such as having the patient well hydrated prior to the procedure, using catheter techniques to minimize trauma, and judicious use of ventriculography, can help to prevent ischemic stroke. 6

Just as with a cardiac emergency, having processes in place to address a stroke event can facilitate positive patient outcomes and save lives. Indeed, Corazon strongly believes in clear, well-thought-out policies, procedures, and processes that activate a stroke code when needed. Initiating immediate patient assessment and intervention could minimize cerebral damage and facilitate positive long-term outcomes in the rare case of a CCL stroke event.
# FIG 1: National Institute of Health Stroke Scale

<table>
<thead>
<tr>
<th>Category</th>
<th>Score</th>
<th>Date</th>
<th>Time</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1a. Level of Consciousness (LOC)</strong> (Alert, drowsy, etc.)</td>
<td>0 = Alert, 1 = Drowsy, 2 = Stuporous, 3 = Coma</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1b. LOC Questions</strong> (Month, age)</td>
<td>0 = Answers both correctly, 1 = Answers one correctly, 2 = Incorrect</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1c. LOC Commands</strong> (Open/close eyes, make fist &amp; let go)</td>
<td>0 = Obey both correctly, 1 = Obey one correctly, 2 = Incorrect</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2. Best Gaze</strong> (Eyes open - pt follows examiner's fingers or face)</td>
<td>0 = Normal, 1 = Partial gaze palsy, 2 = Forced deviation</td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>3. Visual</strong> (Introduce visual stimulus/threat to pt's visual field quadrants. Cover 1 eye and hold up fingers in all 4 quadrants.)</td>
<td>0 = No visual loss, 1 = Partial hemianopsia, 2 = Complete hemianopsia, 3 = Bilateral hemianopsia</td>
<td></td>
<td></td>
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<tr>
<td><strong>4. Facial Palsy</strong> (Show teeth, raise eyebrows and squeeze eyes tightly shut.)</td>
<td>0 = Normal, 1 = Minor, 2 = Partial, 3 = Complete</td>
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<tr>
<td><strong>5a. Motor Arm - Left</strong> (Elevate extremity to 90 degrees and score drift/movement. Count to 10 out loud and use fingers for visual cue.)</td>
<td>0 = No drift, 1 = Drift, 2 = Can't resist gravity, 3 = No effort against gravity, 4 = No movement</td>
<td>NT= Amputation, joint fusion (Explain)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>5b. Motor Arm - Right</strong> (Elevate extremity to 90 degrees and score drift/movement. Count to 10 out loud and use fingers for visual cue.)</td>
<td>0 = No drift, 1 = Drift, 2 = Can't resist gravity, 3 = No effort against gravity, 4 = No movement</td>
<td>NT= Amputation, joint fusion (Explain)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>6a. Motor Leg - Left</strong> (Elevate extremity to 30 degrees and score drift/movement. Count to 5 out loud and use fingers for visual cue.)</td>
<td>0 = No drift, 1 = Drift, 2 = Can't resist gravity, 3 = No effort against gravity, 4 = No movement</td>
<td>NT= Amputation, joint fusion (Explain)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>6b. Motor Leg - Right</strong> (Elevate extremity to 30 degrees and score drift/movement. Count to 5 out loud and use fingers for visual cue.)</td>
<td>0 = No drift, 1 = Drift, 2 = Can't resist gravity, 3 = No effort against gravity, 4 = No movement</td>
<td>NT= Amputation, joint fusion (Explain)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>7. Limb ataxia</strong> (Finger to nose, heal down shin)</td>
<td>0 = Absent, 1 = Present in one limb, 2 = Present in two limbs</td>
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<tr>
<td><strong>8. Sensory</strong> (Pin prick to face, arms, trunk, and legs - compare sharpness side to side, or no feeling at all.)</td>
<td>0 = Normal, 1 = Partial loss, 2 = Severe loss</td>
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<tr>
<td><strong>9. Best Language</strong> (Name items, describe picture, and read sentences. Don't forget glasses if they normally wear them.)</td>
<td>0 = No aphasia, 1 = Mild to moderate aphasia, 2 = Severe aphasia, 3 = Mute</td>
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<tr>
<td><strong>10. Dysarthria</strong> (Evaluate speech clarity by pt reading or repeating words on list.)</td>
<td>0 = Normal articulation, 1 = Mild to moderate dysarthria, 2 = Near to unintelligible or worse</td>
<td>NT</td>
<td></td>
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<tr>
<td><strong>11. Extinction and Inattention</strong> (Use information from prior testing or double simultaneous stimuli testing to identify neglect. Face, arms, legs and visual fields.)</td>
<td>0 = No neglect, 1 = Partial neglect, 2 = Complete neglect</td>
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</tbody>
</table>

**NT=Not Testable acceptable only as noted above**

**TOTAL SCORE:**
### FIG. 2:
THROMBOLYTIC THERAPY
ELIGIBILITY & CONTRAINDICATION IN ACUTE ISCHEMIC STROKE

Date: _____________________      Time: _________________

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INCLUSION CRITERIA</strong></td>
<td></td>
</tr>
<tr>
<td>Diagnosis of ischemic stroke causing a measurable neurological deficit (loss of motor function, aphasia, etc.)</td>
<td></td>
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<tr>
<td>Use caution with major neurological deficits</td>
<td></td>
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<tr>
<td>Onset of symptoms &lt; 4.5 hours before beginning treatment (stroke onset = time patient last seen well or without symptoms)</td>
<td></td>
</tr>
<tr>
<td><em>See additional exclusion criteria for symptom onset between 3.0 to 4.5 hours</em></td>
<td></td>
</tr>
</tbody>
</table>

| **EXCLUSION CRITERIA** |
| Are the patient’s neurological symptoms improving spontaneously? |
| Are the patient’s neurological symptoms minor or isolated? |
| Are the patient’s symptoms suggestive of a subarachnoid hemorrhage? |
| Has the patient experienced head trauma or stroke in the past 3 months? |
| Has the patient had a myocardial infarction (MI) in the previous 3 months? |
| Has the patient had any gastrointestinal or urinary tract hemorrhage in the previous 21 days? |
| Has the patient had major surgery in the previous 14 days? |
| Has the patient had an arterial puncture at a non-compressible site in the previous 7 days? |
| Does the patient have a history of a previous intracranial hemorrhage? |
| Is the patient’s systolic blood pressure > 185mmHg? |
| Is the patient’s diastolic blood pressure > 110mmHg? |
| Does the patient have any evidence of active bleeding or acute trauma (fracture) on examination? |
| Is the patient taking an oral anti-coagulant and is the INR ≥ 1.7? |
| Has the patient received Heparin within the past 48 hours and is the aPTT elevated? |
| Is the patient’s platelet count ≤ 100,000? |
| Is the patient’s blood glucose level ≤ 50 mg/dL (2.7 mmol/L)? |
| Has the patient had a seizure with postictal residual neurological impairments? |
| Does the CT show evidence of a multilobar infarction (hypodensity > 1/3 cerebral hemisphere)? |

**Select Criteria ONLY for those between 3.0 to 4.5 hours**
(in addition to above)

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Is the patient &gt;80 years old?</td>
<td></td>
</tr>
<tr>
<td>Is the patient taking Warfarin Sodium (Coumadin) regardless of INR? (replaces above exclusion criteria)</td>
<td></td>
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<tr>
<td>Does the patient have an NIHSS score &gt; 25?</td>
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</tr>
<tr>
<td>Does the patient have a history of diabetes and prior stroke?</td>
<td></td>
</tr>
</tbody>
</table>

Have the patient and/or family sign the informed consent for Activase (t-PA) administration in the packet.
*(DO NOT delay treatment to obtain consent, no consent is required if patient meets criteria and is unable to sign consent)*

Physician Signature: ___________________  Date/Time: ___________________

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Jan is a Consultant at Corazon, Inc., a national leader in strategic program development for the heart, vascular, neuro, and orthopedic specialties. Corazon offers a full continuum of consulting, recruitment, interim management, and physician practice and alignment services for hospitals and health systems across the country and in Canada. To learn more, visit [www.corazoninc.com](http://www.corazoninc.com) or call 412-364-8200. To reach Jan, email [jyanko@corazoninc.com](mailto:jyanko@corazoninc.com).