The interactions between heart disease and stroke are close and well known. Advances in therapeutics are leading to the development of a broad gamut of interventions, including medical, surgical, and endovascular procedures that are aimed at improving outcomes in persons with severe heart disease. In particular, innovative surgical and endovascular procedures are being used to treat patients who otherwise could not be treated. Unfortunately, these procedures may be accompanied by neurological complications that result in considerable morbidity or even death. Stroke and neuropsychological impairments are well-recognized complications of cardiovascular operations. In addition, cerebrovascular events may follow endovascular procedures, especially those that involve catheterization of the left side of the heart. Although these complications are relatively uncommon, they do have a negative impact on outcomes and survival. The patterns of brain injury include global brain ischemia secondary to hypotension or hypoxia that may cause coma or an encephalopathy; localized brain ischemia secondary to hypoperfusion that appears in a watershed (border zone) or that primarily affects the posterior cerebral hemispheres and leads to visual loss and cognitive deficits; neurotoxicity secondary to contrast agents; intracranial hemorrhage resulting from an idiopathic coagulopathy or from antithrombotic medications; and acute ischemic stroke secondary to embolization of thrombi, air, debris or pieces of atherosclerotic plaque. Besides overt strokes, patients undergoing cardiovascular procedures may have long-term neuropsychological sequelae, including memory loss or impaired executive functioning. In addition, brain imaging performed after procedures also may detect clinically silent or subtle ischemic strokes.

Percutaneous transfemoral aortic valve implantation (PTAVI) is a relatively new endovascular procedure that is being used for treatment of persons judged to be unsuitable for traditional aortic valve replacement surgery. Apparently, many patients having this procedure are elderly and have extensive atherosclerosis of the aorta. Given the population of patients being treated with this intervention, there are issues about survival and safety of PTAVI. Not surprisingly, stroke is a potential complication. With increasing experience with PTAVI and the reports about potential ischemic neurological complications, the article by Kahlert et al in this issue of Circulation is both important and timely. In this German single-center study, the authors evaluated 32 patients who received 1 of 2 different PTAVI devices because of the risk for the development of neurological problems. The authors administered neurological assessments, including the National Institutes of Health Stroke Scale and the Mini-Mental Status Examination (MMSE), and performed magnetic resonance imaging (MRI) of the brain. Neurological outcomes at 3 months were evaluated according to the modified Rankin Scale and the MMSE. They compared the findings among the patients having PTAVI with 21 patients having open heart valve replacement surgery. In addition, the authors looked at variables that may influence the development of neurological complications, including atherosclerotic lesions of the carotid artery or aorta.

The 2 groups of patients were markedly different in baseline characteristics and reflect the selection process for surgery or PTAVI. Those patients having endovascular procedures were significantly older and had severe concomitant health problems. Thus, they were at higher risk for complications. The PTAVI was successful in all of the patients, but nonneurological complications were diagnosed in 9 patients. No clinically overt strokes or neurological worsening were diagnosed among the group treated with PTAVI, and 1 patient in the surgical group had a stroke on the second postoperative day. The MMSE testing did not show declines in cognitive functioning or a difference between the 2 treatment groups. Scores on the modified Rankin Scale and the MMSE at 3 months also were unchanged among the patients treated with PTAVI. Because of the small number of patients, there was low power to detect differences between these 2 groups. Not all of the patients could undergo the MRI studies because of contraindications such as the presence of a pacemaker. The MRI studies demonstrated a high number of ischemic lesions, which were largely small and disseminated in both hemispheres. Lesions were found in 27 of 32 (84%) patients having PTAVI and in 10 of 21 patients (48%) having surgery. The authors concluded that the pattern, size, and location of the lesions would be most compatible with an embolic mechanism.

A showering of small emboli arising from the aorta, the aortic valve or annulus, or the devices seems to be the most likely explanation for the MRI data. The patterns on the MRI correspond with similar imaging results in patients who have clinically silent embolic events complicating carotid artery angioplasty and stenting. As a result, distal protection...
devices are routinely used to prevent the emboli from reaching the brain.\textsuperscript{15} Similar MRI findings also may be observed in patients who undergo diagnostic arteriography or cardiovascular operations.\textsuperscript{7,16} The authors conclude that extensive atherosclerotic plaquing was a risk factor for embolization and that manipulation of the catheters and devices caused fracturing of the plaques and the release of debris. Extensive atherosclerotic plaque formation in the aorta is associated with an increased risk of ischemic neurological events, including in the setting of invasive cardiovascular procedures of cardiovascular surgery.\textsuperscript{7,18}

The authors conclude that the embolic events were clinically silent—a conclusion that may not be accurate. Because the MRI lesions appeared to be small, major neurological abnormalities likely were not going to be found; however, a showering of emboli to multiple brain areas may have caused subtle cognitive impairments that may have been missed by the MMSE, which is not a sensitive test to detect the types of behavioral or cognitive abnormalities that may be present. The study could have been strengthened if more detailed neuropsychological testing had been performed. Such batteries of tests have been included in studies evaluating the neurological consequences of cardiovascular operations.\textsuperscript{2}

The results of the study by Kahler et al\textsuperscript{11} should stimulate future clinical research on testing the safety of PTAVI and other innovative endovascular cardiac operations. The lessons of this study may be used to plan the next series of clinical studies and may lead to innovative techniques or ancillary care to increase patient safety. Future studies should involve the collaboration of cardiologists, vascular neurologists, neuropsychologists, and neuroradiologists. A carefully defined protocol could be used to detect both serious and subtle neurological impairments and any clinical imaging correlations. Such studies will be a springboard for new methods for cerebral protection.

Pending the results of such future studies, the results of the study by Kahler et al\textsuperscript{11} may influence patient care. The selection of patients could include an increased emphasis on the extent of aortic atherosclerosis. Changes in the techniques or devices, such as the development of new catheters to facilitate delivery or the creation of small arterial sheaths to limit arterial injury, also may improve the safety of PTAVI.\textsuperscript{9}

It is unclear whether protection devices can be safely inserted into the major branches of the arch of the aorta in a way similar to that used to protect the brain during carotid angioplasty and stenting. There is a real concern that further manipulation of devices within an aorta that has extensive and advanced plaque formation may further increase the risk for neurological morbidity. In the future, the use of prophylactic neuroprotective medications also may limit a broad variety of neurological complications of these procedures.\textsuperscript{19}

The development of new endovascular cardiac procedures is exciting. As these advances evolve, a detailed plan to monitor for adverse neurological consequences should be included.

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References


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