The Neurointerventional Suite as an Acute Stroke Intervention Unit

A streamlined plan to evaluate and treat acute ischemic stroke may improve outcomes and save lives.

BY CHARLES M. STROTHER, MD

Increasing experience and evidence emphasize the essential relationships between the time interval from onset of symptoms of an acute ischemic stroke and the likelihood of both successful revascularization and a favorable clinical outcome. Closely linked to this is the recognition that proper patient selection for endovascular therapy is essential in minimizing the incidence of failed or harmful interventions. Thus, there is solid motivation for investigators to identify and develop techniques and processes that will provide accurate anatomic and physiological information for diagnosis while simultaneously shortening the interval from when a patient arrives at a hospital to the time when a decision can be made regarding appropriate management (ie, whether an attempt at revascularization is indicated).

Once a patient has been identified as having neurological dysfunction as the result of ischemia, optimization of further management then requires exclusion of any subarachnoid or parenchymal hemorrhage, determination of the extent and location of neurological injury, establishment of the level of viability of ischemic tissue (ischemic core or penumbra), and identification of the etiology of the ischemic injury. It would be ideal if diagnosis and intervention could be performed in one suite, minimizing the time to revascularization in appropriately selected patients.

Currently, in most hospitals, decisions regarding patient selection for cerebral revascularization are made using combinations of either computed tomography (CT) or magnetic resonance imaging (MRI) protocols, which provide both physiological and anatomical information. There is solid evidence to suggest that perfusion imaging may be a better determinant than time from onset when choosing patients for revascularization, although this is not universally accepted.[1,2] I firmly believe that a physician armed with imaging data indicating perfusion parameters and visualizing the origin of vascular occlusion will make a more informed decision when choosing acute stroke patients for revascularization than if this information is not available. Using time from onset of stroke as the sole determinant for intervention appears arcane.

EXPERIENCE WITH A SINGLE-MODALITY FACILITY

To avoid moving acute ischemic stroke patients from the emergency department to CT and/or MR imaging suites to facilitate diagnosis and triage and then, when revascularization is indicated, to the angiographic suite, a single room capable of providing not only the anatomical and physical information obtained from CT and/or MR but also providing the ability to perform vascular interventions would seem to add value simply because such a facility could reduce the time from a patient's arrival at a stroke center to the onset of treatment.

During the last 3 years, in conjunction with scientists and engineers from Siemens Healthcare's (Malvern, PA) angiography division, we have worked to develop and evaluate imaging techniques that would provide the diagnostic information necessary to identify patients who are most suitable for revascularization while decreasing the interval from a patient's arrival at the hospital to onset of treatment simply by avoiding the need for transfer between one imaging modality and another (ie, CT or MR to the angiography suite). Although such a transport may, in theory, seem simple and fast, in reality, in many instances, it is often complex and quite time consuming.

Using a Siemens flat-panel detector angiographic system, we have developed a technique that, from a

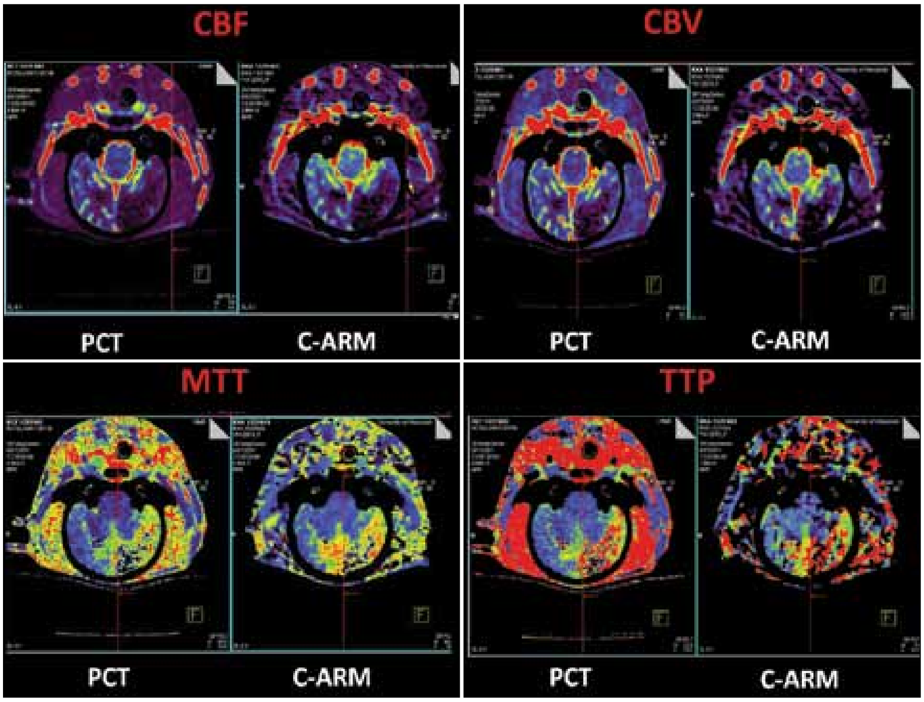

Figure 1. Comparison of perfusion maps made using standard perfusion CT (PCT) and a Siemens flat-panel detector angiographic system (C-arm). These maps were obtained 4 hours after creation of a middle cerebral artery occlusion. Cerebral blood volume (CBV), cerebral blood flow (CBF), mean transit time (MTT), and time to peak (TTP) were measured with both modalities. There is good correlation between the maps made with each modality.

single rotational angiographic acquisition, provides a three-dimensional (3D) reconstructed volume of the intracranial vasculature, a noncontrast C-arm CT scan, and a CBV map. Our experimental results have been described in two publications in the *American Journal of Neuroradiology*, and Struffert and colleagues have published their clinical experiences using a similar technique in the same journal, as well as in the *European Journal of Radiology*.[3-6] More recently, we have developed and tested an angiographic acquisition protocol that provides not only CBV maps but also maps of CBF, MTT, and TTP. The results of these experiments will be presented at the upcoming meeting of the American Society of Neuroradiology in April of this year (Figures 1 and 2).

Much more experience must be obtained to determine what role these developments will and should play in clinical practice. Experience to date, however, is sufficient to state that it is feasible to obtain high-quality physiologic as well as anatomic information in the angiographic suite. In animal and in-human studies, CBV measured with flat-panel detector angiographic systems have compared very well with those that are made using conventional PCT. In early animal studies using a dynamic acquisition protocol CBV, CBF and MTT measured with the Siemens angiographic system also compared well with ones obtained using conventional PCT.[5]

PROPOSED USES

Suppose that: (1) ongoing evaluations with this technique continue to yield similar results to those achieved thus far; (2) the ability to obtain dynamic measurements of CBV, CBF, and TTP, which we have demonstrated in animal studies, is confirmed in humans; and (3) ongoing improvements in detector technology and reconstruction algorithms converge so that flat-panel detector CT images are adequate to exclude subarachnoid or parenchymal hemorrhage. How then might these advances be used in clinical practice?

Consider the following. A patient with symptoms of an ischemic stroke arrives at a regional stroke center. After clinical evaluation, instead of undergoing CT or MR imaging, the patient is brought directly to the angiography suite where, in conjunction with an intravenous injection of contrast medium, a single rotational acquisition is acquired. The noncontrast CT scan shows no sign of hemorrhage, the reconstructed 3D volume of the vasculature shows an occlusion in the M1 division of the left middle cerebral artery (LMCA), the CVB map shows an increase in CVB in the distribution of the LMCA as compared to the same distribution in the opposite (normal) cerebral hemisphere, and CBF and MTT are both elevated in this same area.

Using this information, a decision is made that, due to a large artery obstruction and evidence of ischemic but still viable brain parenchyma, it is appropriate to attempt revascularization. The procedure is started within a very short time of the patient's arrival in the angiography suite. After working for more than an hour, the LMCA is still occluded. To assess whether or not the revascularization attempt should be continued, another perfusion measurement is taken. If the CBV map shows that CBV in the LMCA territory is now decreased as compared to previous levels (and the opposite normal side), the

Figure 2. The angiography suite used for the endovascular treatment of acute ischemic stroke patients at the University of Wisconsin, Madison Hospitals and Clinics. Drs. Beverly Aagaard-Kienitz and David Niemann are responsible for the care of these patients.

procedure is terminated. If the CBV map shows that the CBV in the LMCA territory is unchanged from the earlier measurement and is still elevated as compared to the normal MCA distribution, the procedure is continued.

This workflow should save a significant amount of time compared to the current practice, and the information provided should improve the ability to select patients who are most likely to benefit from revascularization efforts. Data from large numbers of patients treated with this approach should (by categorizing patients into homogeneous groups) improve the ability to design and understand the results of clinical trials evaluating revascularization procedures.

Today, it is not possible to either completely exclude the presence of hemorrhage or to measure perfusion parameters (other than CBV) using flat-panel detector angiographic systems. Nonetheless, it is still possible today to perform sufficient vascular and perfusion assessments in the angiographic suite to allow initial triage and, if appropriate, revascularization. Thus, we can identify a group of patients who would benefit from a single acute stroke treatment room. These are patients who come to a stroke center having had a conventional CT scan that excludes the presence of hemorrhage and show clinical or CT evidence of what is likely a large artery occlusion (eg, MCA or basilar). An initial angiographic acquisition provides a 3D vascular volume that has better spatial resolution than CT angiography; the CBV map from the same acquisition provides information regarding the size and viability of the ischemic brain tissue.

Sequential measurements of CBV can provide information regarding changes in tissue viability, which may occur when procedures are of long duration. This likely would add value in determining when continued efforts at revascularization are no longer indicated.

Although our efforts have been focused on evaluating the utility of these techniques in patients with acute ischemic strokes, they are also obviously applicable to patients presenting with a documented subarachnoid hemorrhage (the ability of C-arm CT to detect small amounts of blood in the subarachnoid space remains unproven). In such patients, from a single acquisition the reconstructed noncontrast CT would allow evaluation of ventricular size, and the reconstructed 3D vascular volume would allow detection of any vascular abnormalities responsible for the hemorrhage as well as determination regarding the appropriate treatment technique (ie, endovascular or craniotomy).

CONCLUSION

As investigators expand their usage of flat-panel detector angiographic systems to provide high-quality images not only of brain parenchyma and vasculature but also physiologic information about blood flow and tissue perfusion, experiences using the previously discussed techniques will rapidly increase. It is important that those using these techniques establish trials designed in such a way so that credible evidence can be obtained regarding whether or not these methods add value to the conventional techniques now used for the treatment of patients with acute ischemic stroke. It is an exciting time to work in the evolving and enhanced environment of the angiographic suite. Will this model become the stroke unit of the future? ■

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