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Transcranial Doppler usefulness in balloon angioplasty

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Introduction

Cerebral vasospasm remains a significant complication of subarachnoid hemorrhage following ruptured aneurysm [1,2]. Transcranial Doppler (TCD) has proved useful in diagnosing spasm of the basal cerebral vessels and also useful following the development and resolution of vasospasm over time [3,4]. One of the newer treatments for cerebral vasospasm which has shown effectiveness is transluminal angioplasty [5–8]. First introduced by Zubkov et al. [8] in 1984, this procedure employs a microballoon catheter which is inserted in the spastic arteries and then is used to mechanically dilate them, restoring blood flow to the ischemic area of the brain. Persistent dilation of the arteries has been documented using TCD [7] and improvements in blood flow have been demonstrated following the procedure. TCD has been useful in documenting the persistent effect of angioplasty as well as monitoring arteries which were not treated by the angioplasty procedure for the development of critical vasospasm.

Methods

Between July 8, 1988 and April 1991, thirty-one patients at the University of Washington have been treated with transluminal angioplasty for vasospasm following subarachnoid hemorrhage. Twenty-nine patients had subarachnoid hemorrhage and ruptured intracranial aneurysms, and in one patient no source of bleeding was found. One patient sustained a minor head injury with significant subarachnoid hemorrhage and later developed symptomatic vasospasm. The usual management protocol for the patients for subarachnoid hemorrhage included early surgery for ruptured aneurysm regardless of the grade (within 72 h of rupture) when referral permitted. All patients underwent 4-vessel angiography before surgery and postoperative angiography to confirm clip placement. Patients were monitored in the intensive care unit using arterial blood pressure monitoring, intracranial pressure monitoring and in cardiac output monitoring using Swan-Ganz catheters. Patients were treated with hypervolemia and during the later part of the series, also with calcium channel blockers. Baseline TCD examinations were performed on most patients except some patients referred from other institutions for angioplasty. TCD examinations were repeated at regular intervals, usually daily, to follow the

SPECT scanning performed before and after treatment showed improvement of regional central perfusion in the majority of patients studied. The patients with improvement in regional perfusion also showed clinical improvement.

Discussion

Experience with transluminal angioplasty for vasospasm is accumulating in many centers now and initial results have been very favorable in patients who otherwise have a poor prognosis [6,7,9,10]. It is not entirely clear why the procedure works and why the treated arteries do not re-stenose. There are experimental studies which demonstrate that vasospasm is not a mere muscular contraction of the arteries, but that structural changes take place in the vessel wall [11–13]. TCD has clearly demonstrated that the effect of dilating the artery is sustained and that mechanical dilation interrupts the pathogenic process. This is especially illustrated by the fact that cases have been observed in which a treated vessel can maintain a low velocity following angioplasty whereas untreated vessels can continue further narrowing due to the vasospastic process. Perhaps the most useful role that TCD plays in examining patients following angioplasty is to monitor the vessels which were not spastic at the time of the original treatment but which then may go on to develop critical vasospasm. SPECT scanning has also confirmed that the effect of the procedure is prolonged and that sustained improvements in the cerebral blood flow to ischemic territories can be achieved. SPECT showed an excellent correlation with clinical improvement following the procedure. The results of these findings have prompted investigators to rethink the pathogenesis of vasospasm and further laboratory work is needed to study this phenomenon in further detail.

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vasospasm. Patients were selected for angioplasty if they had a new onset of a neurological deficit (including decreased level of consciousness) despite maximum treatment. Other causes of deterioration were ruled out (hydrocephalus, edema, intracerebral hemorrhage) by CT scan. Angiograms were performed on all patients who were candidates for angioplasty to confirm vasospasm. The procedure was performed if there was spasm present in an accessible vascular distribution which could account for the symptoms, and there was no infarction present on the CT scan.

Angioplasty was performed using several types of catheters which were custom made for this purpose. Polyethylene microballoon (Target Therapeutics Corporation, San Jose, California) and a silicone microballoon (Interventional Therapeutics Corporation, South San Francisco, California) were used. The procedure is either performed under general anesthesia or sedation. High resolution fluoroscopy with road mapping capabilities was used to guide the catheter. Heparinization is performed with reversal at the conclusion of the procedure. Angiography is repeated at the end of the procedure to confirm vessel dilations. Following the procedure, patients are continued on calcium channel blockers and hypervolemic treatment. TCD examinations were done with the Medasonics Transpect or an EME T-264B. Patients were re-examined at regular intervals (usually daily or every other day) following the procedure for one week.

Ten patients had single photon emission computerized tomography (SPECT) scans performed immediately preceding and then 12 to 36 h following the angioplasty procedure to evaluate regional cerebral perfusion. Scanning was performed after intravenous administration of 25 to 35 mCi of TC-99m hexamethyl propyleneamine oxine (HM-PAO) or 1.5 mCi of I^{123} idoamphetamine (spectamine). Tomographic acquisition was performed using a 400 AT gamma camera (General Electric, Milwaukee, Wisconsin) linked to a microdelta computer.

Results

Twenty-three of the 31 patients who underwent this procedure had clinical improvement. Improvement was defined as increase of the Glasgow coma score by 2 points or significant improvement in speech or motor deficit. Seven deaths occurred. Three were from rupture of unclipped aneurysms and one from vessel rupture. Two patients died after failing to improve from poor grades after successful angioplasty and one patient died from vasospasm in an inaccessible region due to previous carotid occlusion. TCD values in the proximal middle cerebral arteries and distal internal carotid artery trunks were decreased following the procedure in all patients except one. These velocity values remained below preangioplasty levels during follow-up examinations in all but this one patient. On numerous occasions, vessels other than the treated vessels developed increasing velocities during the follow-up period despite the fact that velocities in the treated vessels remained low. In certain patients, significantly higher velocities were observed in more distal portions of the treated artery than were present prior to the procedure.