Block of Arachnoid Villus by Subarachnoid Hemorrhage*

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The recent emergence of the syndrome of occult hydrocephalus\(^2,4,10,15,16\) has provoked an intensified search for etiologic and pathogenetic factors underlying this entity. From a review of the relevant literature it appeared to us that the arachnoid villus block merited further exploration.

The possibility of obstruction of the cerebrospinal fluid pathway by blockage of the arachnoid villi has been discussed by many investigators.\(^1,12,18-21,28\) Russell, in 1949,\(^19\) stated that "retardation of absorption of the cerebrospinal fluid into the venous blood through the arachnoid villi is at least a theoretical cause of hydrocephalus." Zülch stated that the "possibility of a blockage of the arachnoid granulations by diffuse arachnoidal bleeding . . . has been discussed in the literature, yet anatomical observations do not seem to support the idea."\(^28\) In 1952 Denny-Brown observed "amorphous material plugging the Paccionian Bodies" of a patient with infectious polyneuritis and "external hydrocephalus."\(^7\) In 1960, Turner observed "blood elements" in the "arachnoid granulations" after death from subarachnoid bleeding. Foltz and Ward\(^9\) and Strain\(^22\) over a decade ago reported examples of symptomatic hydrocephalus as a sequel to subarachnoid hemorrhage. Recently, Hogan and Woolsey\(^11\) reviewed 50 cases of adult hydrocephalus which included 12 attributed to subarachnoid hemorrhage; arachnoid villus block was once again suggested as a possible cause, but the process was not demonstrated.

To determine whether this postulated block might actually be demonstrable, we took advantage of the opportunity to examine particularly the superior sagittal sinus of a patient (Case 1) who had died of head trauma. In this instance, the villi were indeed blocked, being distended and densely packed with blood. This observation prompted the study of the six cases of subarachnoid hemorrhage of traumatic, operative and spontaneous origin which are described below.

Methods

The brain was removed in the usual manner; the dura was then separated from the cerebral arachnoid and fixed in formalin. Although some villi were avulsed during this procedure, and remained attached to the leptomeninges, most retained their anatomic relations to the superior sagittal sinus. The outer wall of the sinus was opened longitudinally and its channels and recesses explored with the aid of a Zeiss operating microscope. Findings were recorded by photographs at magnifications of 3\(\frac{1}{2}\) to 11. Transverse sections were selected for histologic study. Masson stain was used because it clearly showed in green the collagenous structure of the dura, the arachnoid villus, its meshwork of arachnoid trabeculae, and its covering of venous endothelium; the erythrocytes, stained red, stood out in sharp contrast. We routinely examined only the superior sagittal sinus, omitting study of villi in other dural sinuses and spinal root cuffs.\(^6,20\) Since this is the location of most arachnoid villi as well as the major site for absorption of cerebrospinal fluid, these observations were considered to provide a reliable index of the relative degree of arachnoidal block.

Case Reports

Each of the following patients died within a few days of the acute subarachnoid bleeding, and at postmortem examination all had parenchymatous swelling of the brain, with narrowing of the sulcal subarachnoid space and compression or distortion rather than expansion of the ventricles. In each case we

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give brief clinical history, pertinent pathologic findings regarding the hemorrhage, and a qualitative description of the villi.

Case 1 (Head Trauma in Auto Accident). This 21-year-old man was admitted comatose but responding to painful stimuli with flexion of the extremities. He had an open, depressed, left frontal skull fracture with a dural tear through which brain oozed. Operative decompression was done upon admission, but he soon became decerebrate. Death occurred 6 days later.

Extent of hemorrhage. There was a ragged laceration of the left frontal pole with marked surrounding hemorrhage that tapered off into the subarachnoid space and convexity sulci. There were also severe contusions, mainly of the left frontal and right occipital lobes. In addition, there was small subdural hemorrhage lining the anterior and left middle fossae.

Arachnoid villi. The arachnoid villi were nearly all deep reddish-black and had the appearance of tensely distended sacs (Fig. 1 left). When viewed under the dissecting microscope, many villi were observed to have tiny diverticulae bulging between the tautly stretched dural trabeculae (Fig. 1 right). Their appearance suggested impending rupture, but definite tears in the membrane were not demonstrated. Histologic sections of the sinus showed dense packing of the villi with blood, with little cerebrospinal fluid space remaining (Fig. 2). Basally, the meshwork of arachnoid trabeculae in the villi was generally denser and its spaces contained many red cells, while near the domes of the villi this meshwork appeared looser and red cells were packed more tightly, as though squeezed into the subendothelial space. This appearance may have been produced in part by fixation shrinkage of the collagenous villus core, as described by Turner. Despite the tense appearance, the endothelial covering appeared intact and continuous (Fig. 3). This case demonstrates maximal distention and complete obstruction of villi by impacted red cells.

Case 2 (Ruptured Aneurysm). A 37-year-old woman had severe headache, nausea, and lethargy for a week preceding admission. She was oriented but dull, with a left hemiparesis and sensory extinction. Arteriography revealed a right middle cerebral aneurysm. This was clipped after evacuation of a temporoparietal intracerebral hematoma. The following morning she seemed more alert. Lumbar puncture showed a pressure of 430 mm CSF with 2240 red blood cells (RBC) per cu mm and a protein content of 114 mg%; 10 cc were removed with a closing pressure of 200 mm CSF. She slowly