The Macro and Microvasculature of the Dura Mater*

C.W. Kerber and T.H. Newton
Department of Radiology, University of Oregon Medical School, Portland, Oregon, USA, and Division of Neuroradiology, University of California, School of Medicine, San Francisco, California, USA

Summary. The basic microvascular anatomy of the human dura is described. The named dural arteries give rise to two outer anastomotic sets of vessels. From the outer arteries, penetrating vessels descend to supply a rich capillary network located near the arachnoid. Arteriovenous shunts are present in the midportion of the dura, which may function to bypass the capillary network.

La vascularisation et la microvascularisation de la Dure-mère

Die makro- und mikro-Vasculatur der Dura

The major arteries present on the dura are well known, and have been carefully described [1, 2, 6, 7, 8, 12, 14]. The smaller vessels, however, have received little attention from investigators, and save for the work of Rowbotham and Little [9, 10], the general impression exists that the dura is an avascular, fascia-like membrane. This concept is summarized in Gray’s Anatomy which describes the dura only as a “thick and dense inelastic membrane, . . . lining the interior of the skull and serving the twofold purpose of an internal periosteum to the bones and a membrane for the protection of the brain” [4]. This misconception is understandable if one examines only standard histological preparations. These emphasize the connective tissue strata of the dura while collapsing the smaller vessels (Fig. 1).

The recent work of Gooding, et al., [3] showing the rapid accumulation of contrast in the dura after its intravenous injection, and the gross observation of minute vessels on the inner or cranial surface at the autopsy table, prompted us to investigate the basic vascular bed of the dura mater.

Materials and Methods

Human specimens were obtained within 24 h of death by gently stripping the dura from the skullcap. With a dissecting microscope, the largest visible arteries were cannulated, and warm saline at physiological pressures was injected to remove as much blood as possible. Following this, a barium gelatin suspension [5] was introduced and contact microradiographs were made (Fig. 2).

Other human specimens were injected with colored gelatin suspensions; these were then fixed, dehydrated and cleared with alcohol and methylsalicylate.

Three dog duras were perfused after anticoagulation and sacrifice of the animal. These specimens were removed after solidification of the gel, and fixed and cleared as above.

Portions of the specimens were mounted on large glass slides and studied with a dissecting microscope, which allowed an appreciation of the three dimensional path of the vessels.

Data

The main meningeal arteries are often visible angiographically, and lie on the outer or periosteal surface of the dura. They are not included in this study, as they are well described in standard texts. These vessels are approximately 400 to 800 microns in inner diameter. The named arteries give rise to a rich anastomotic layer of vessels which are also on the outer or periosteal surface. These we have called the primary anastomotic arteries (PAA).

The PAA have two main characteristics. First, their diameters change very little as they course over the dural surface, even when they are far removed from the parent artery. Second, they anastomose freely and frequently with each other, and with the major meningeal vessels (Figs. 3, 4).
Fig. 1. A coronal section of human dura from the midparietal region stained with hematoxylin and eosin. The standard histological techniques emphasize the collagenous character of the dura while collapsing the small vessels. Only a few small veins are visible in the region of the superior sagittal sinus. SS - sagittal sinus.

Fig. 2. A contact microradiograph of human tentorium. This representative area has been injected with barium-gelatin mixture showing the unexpected complexity and richness of the vascular network. By this technique, the origin and termination of the vessels are difficult to determine, and there is some distortion of the vessels which are far from the photographic plate. Magnification factor: 100 X.

Figs. 3 and 4. An *en face* view of human dura from the low parietal region, injected with colored gelatin. This demonstrates the vessels lying upon the periosteal dural surface to best advantage. The closed arrows indicate primary anastomotic arteries. These vessels interconnect freely and change diameter very little as they course over the surface of the dura. The torn ends of several of the vessels which supply the metabolic needs of the skulls are also visible (open arrows). Magnification factor: 3 X.

These arteries cross the superior sagittal sinus frequently, connecting the two dural hemispheres into a single vascular unit (Fig. 5). The crossing vessels are particularly large when one middle meningeal artery is hypoplastic.

As a rule, the primary anastomotic arteries are quite straight, but occasionally, an extremely serpiginous variant is visible. The significance of this latter vessel type has not been determined.

The PAA measure 100 to 300 microns in inner diameter.

These vessels give rise to four smaller arterial units: the arteries to the skull, the secondary anastomotic arteries, penetrating vessels (probably arterioles), and arteriovenous shunts.

When the dura is stripped from the skull, many small arteries are torn out of the diploe. The ends of these vessels are visible on the outer surface of the