BLOOD SUPPLY OF PRIMARY AUDITORY CORTEX IN CHINCHILLA: A CORROSION CAST STUDY

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INTRODUCTION: The chinchilla animal model is widely used to study the function of the auditory system. The location of auditory cortex in the chinchilla has previously been determined both electrophysiologically and by optical imaging of intrinsic signals. The spatial resolution of functional imaging techniques which rely on changes in the BOLD (blood oxygen dependent level) signal to create images of activity (i.e., fMRI and optical imaging) are ultimately dependent on the resolution of microcirculatory control mechanisms. For example, in response to pure tone auditory stimuli, functional resolution (within cortex) of approximately 400 µm has been demonstrated using optical imaging. To better understand the limits of functional imaging the present study was undertaken to explore the structure and properties of the arterial supply within auditory cortex.

METHODS: Plastic casts of the cerebral vasculature were prepared by cannulating the ascending aorta, incising the right atrium and then perfusing 50 ml heparinized PBS followed by 20 ml of Batson's #17 resin. The animal was left 12 h at room temperature to allow complete solidification of the resin, the brain was then dissected free. The perfused brain was photographed then macerated in 40% KOH at 50°C for 24 h with intermittent rinses in distilled water. The corrosion cast was air dried, photographed, mounted onto a stub with colloidal silver and sputter coated with gold. The cast was examined in an Hitachi S570 SEM at 10-15 keV. All procedures were performed within the standards of care of the local animal care committee and in accordance with the guidelines of the Canadian Council on Animal Care.

RESULTS: Figure 1A indicates the location of auditory cortex within the temporal lobe. Auditory cortex is supplied with blood via the middle temporal branch of the medial cerebral artery (MCA) which in turn arises from the arterial circle between the frontal and temporal lobes, travels laterally and superiorly giving rise to three main arteries supplying the temporal lobe: the inferior, the superior and the middle temporal arteries. The middle temporal artery (MTA) bifurcates into superior and inferior branches.

In response to acoustic stimulation, local hemodynamic changes within auditory cortex can be monitored using optical imaging of intrinsic signals. Figure 1B shows the area of intrinsic signals arising in response to a 60 dB noise stimulus, the response area encompasses primary auditory cortex (AI), secondary auditory cortex (AII) and the anterior auditory field (AAF). In the majority of subjects the primary auditory cortex is located about the bifurcation of the MTA.

Figure 1C shows the corrosion cast of auditory cortex blood supply viewed at a right angle to the cortical surface. The lower surface of both the inferior and superior middle temporal arteries give rise to collateral vessels which directly penetrate the cortical surface. In addition there are a number of sidebranching collateral vessels which tend to either extend from the artery at right angles across the cortical surface for a short distance (~ 500 µm) before penetrating the surface, or have a superficial course of several millimeters before becoming intracortical. The intracortical arteries tend to be of short, medium or long length. The short arteries give rise to a capillary bed approximately 750 µm deep located in the superficial layer of cortex. The medium and long arteries give off few if any collateral branches within the area of this capillary bed. Medium length intracortical arteries frequently terminate or bend at 90° and course parallel to the cortical surface at a depth of 1 mm, branches of these vessels also contribute to the capillary bed. Within the superficial capillary bed arterioles give off both collateral and terminal capillaries. Even on well filled casts the capillary bed appears to be of uneven density (fig. 1D). Plastic strips, likely replicas of smooth muscle cells, are found only on intracortical arteries and precapillary arterioles, most frequently at branching points (fig. 1E).

REFERENCES

Figure 1. A) The black circle indicates the general location of auditory cortex within the temporal lobe of chinchilla. B) Area of BOLD signals in response to a 60 dB noise stimulus (outline); location of primary (AI) and two secondary auditory areas (All & AAF) are indicated. C) Corrosion cast of cerebral vasculature in the region of auditory cortex. Surface vessels, penetrating arterioles and the superficial capillary bed can be seen. D) Within the capillary bed there is an uneven distribution of capillary density. Elongated imprints of endothelial cell nuclei are present on the surface of the intracortical artery and its branches. E) Plastic strips (arrowheads), are found surrounding intracortical arteries and precapillary arterioles only (see panel D also). Note the narrowing of the capillary at its point of origin. A, artery; V, vein; P, precapillary arteriole; C, capillary