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Computed Tomography of the Brain in Axial, Coronal, and Sagittal Planes

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Foreword

The introduction of a new technology in medicine has frequently been accompanied by an initial surge of great enthusiasm. A period of equilibration has usually followed, during which the contributions of the method have been more sharply defined and its place in medicine assessed. Thereafter, the technology may reach a plateau defined by its level of professional acceptance; may gradually decline as other competing technologies develop and are introduced; or may abruptly terminate when something clearly better and more efficacious appears. Some innovations, such as the hyperbaric oxygen chamber, have been expensive failures and have ridden the crest of enthusiasm briefly. Others, such as internal mammary ligation and internal mammary implantation, have been profoundly invasive in character, and have had extravagant "triumphs," though unverified by controlled, randomized studies.

In radiology, the last revolutionary change was the introduction of image intensification in the late 1940s. For the first time it was possible to remove the fluoroscopic process from a darkened room, to effect a major gain in luminance, and to do so without increasing the radiation dose to the patient. Image intensification has now become an integral element in the fabric of contemporary imaging, with striking improvements over the decades since its introduction and with increasingly better resolution of the modern image intensifiers.

At the beginning of this decade, Hounsfield combined for the first time developments in modern computer technology with the known capacity to translate digitized information obtained from multiple angles into three-dimensional or cross-sectional images. The initial applications of computed tomography (CT) to the brain were dictated by the long scan-time and the need for immobilization of the part being examined. Competition with other imaging methods was limited. The skull film offered little information about the intracranial contents in a wide range of disorders. Radionuclide brain scanning was the real competition, a method that was relatively sensitive but not highly specific and that provided a resolution that was not competitive with that of computed tomography.

With the first primitive images of the brain, it became apparent that CT was the beginning of a revolution in modern radiology. The developments since that time—the movement from a four-minute to a two-minute scanner, then to an eighteen-second, and finally to the modern generation of one- to five-second scanners—have come tumbling out of the research laboratory and have quickly been applied to man. In body CT, the short-time scanners are now capable of resolution undisturbed by respiratory-motion blurring, and the images obtained of the intrathoracic and intraabdominal contents are superb. Similar developments have occurred in brain CT scanning and have established ever more firmly the important role of CT in neurologic and neurosurgical practice; it is now a central method of neuroradiology.

With the introduction of brain CT and body CT there has come a rediscovery of and a heightened interest in cross-sectional anatomy. In this volume, Drs. Binder, Haughton, and Ho have collaborated to produce an extraordinarily beautiful and valuable piece of work. They have depicted cerebral anatomy in the axial, coronal, and sagittal planes so as to provide analogues for the images obtained on computed tomography. The volume clearly represents a prodigious amount of work, a labor of love which will remain a classic treatise on comparative gross anatomy and roentgen anatomy of the brain. For many years to come it will provide a definitive framework for distinguishing normal anatomic arrangements from pathologic anatomy.

Comparing the gross anatomic section side by side with the CT image, the reader will find a careful and detailed labeling of each anatomic landmark. He will have available the best kind of reference work, a volume to which every brain CT slice on patients can be brought for comparison with the assurance that variations have been taken into account. Radiology is, after all, our most important means of depicting the normal and abnormal gross anatomy of the viscera in living man. It does so with a degree of resolution and accuracy that renders it the most valuable tool available for the diagnosis of gross visceral disease. To a host of conventional and invasive diagnostic methods, CT has added a means of accomplishing what was never before fully available: a consistently reliable delineation of transaxial anatomy in all areas of the human body.

Clearly, this is a book that is meant for all those involved in the neurologic sciences as well as in radiology, and one that will occupy a place as important in the office as in the medical-school library. The authors have done us a great service by their meticulous dissection of an organ and of its images, and by recording it so elegantly that all of us can use and profit from it.

Herbert L. Abrams

Preface

This atlas developed from a need to identify intracranial structures visualized on CT images of patients scanned at our hospital. Although some structures on the CT images could be identified because of their characteristic shape or location, the identity of others could only be inferred. Available atlases were found to be unsatisfactory since the angles or levels of section did not always correspond to our own CT images. Brain-specimen scanning solved that problem by allowing exact comparisons between CT images and anatomic slices to be made. We were extremely careful to slice the brain at exactly the same angle and level as the corresponding CT image. Since CT in the axial plane is usually performed at 20 degrees to Reid's baseline, we have made every effort to image the brain as close to that angle as possible. Now that scanners are capable of imaging or reconstructing images in coronal and sagittal planes as well, those views are also presented.

We have attempted to demonstrate the remarkable similarity between the CT image and its corresponding anatomic section as clearly and simply as possible. All pairs of images and sections are oriented side by side. All CT images have been enlarged to correspond in size to the prints of the anatomic sections. Extensive time has been spent in labeling the illustrations. Structures that are identified in the CT image are always identified on the corresponding section. The leader arrows in both the image and the section are arranged in a symmetrical format to allow for ready comparison.

We devote a chapter to the identification of the surface anatomy of the brain because such identification is valuable in orientation as well as in recognition of the different lobes of the brain. Particular emphasis has been placed on identifying structures of the cerebellum, brain stem, and base of the brain, since these areas have been neglected in other textbooks of anatomy but are common sites of disease.

The EMI MARK 1 (160 × 160 matrix) head scanner has been used exclusively for the atlas section of the book. Although there are shades of difference in the images obtained from different head scanners, we think that our images can be readily utilized. Calvarial artifacts that are common with the EMI MARK 1 scanner have been obviated by removing the brain from the cranial vault. A separate section, "Comparison of CT Scanners," has been added to demonstrate some of the basic differences that exist with currently available scanners.

Computerized tomography is no longer a research tool found exclusively at the university. As resolution improves and anatomy is better delineated, more detailed anatomic atlases are required. It is hoped that this atlas will help the practicing physician keep pace with the rapidly evolving field of computerized tomography.

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Chapter 1

Introduction

In this atlas, computed tomographic (CT) images are displayed side by side with the anatomic sections of the brain from which they were obtained. Intracranial structures are identified precisely on the CT image by reference to the anatomic section. Cadaver brains were used to ensure that exact comparisons were possible and that CT images were free from motion, beam hardening, and overshoot artifacts. In CT scanning, the coronal plane has become a useful adjunct to the axial view, and in many scanners sagittal projection is possible by reconstruction techniques. Therefore, in this atlas, brain anatomy is illustrated in coronal and sagittal planes as well as in the conventional axial plane. Images from the EMI MARK 1 were chosen for the atlas, although we scanned brain specimens on several models of CTscanners including the EMI 5005, EMI 1010, Ohio Nuclear Delta 25, Ohio Nuclear Delta 50, Artronix Neurocat, General Electric CT/T 7800, General Electric CT/T 8800, and Pfizer 0200 scanners. Because differences do exist between images obtained from these different scanners, however, we have discussed these differences in Chapter 6.

For each projection, a normal formalin-fixed brain of approximately 1200 gm was used. Prior to imaging, each specimen was submerged in water and rotated to eliminate any air trapped in the ventricles. While still submerged, each brain specimen was transferred to its own cone-shaped polyethylene container,* which was then sealed with an airtight lid. The container was then removed from the water and positioned in the CT scanner. Scans were made with the EMI MARK 1 (160 × 160 matrix) scanner at 120 kv and 33 ma. Consecutive 5-mm scans were obtained using 8-mm (fine-focus) collimation. Axial images were obtained by positioning the container in the scanning gantry so that the base of the brain was parallel to the plane of cut. Coronal images were obtained with the plane of scanning approximately perpendicular to the base of the brain. Sagittal images were obtained with the plane of scanning parallel to the longitudinal cerebral fissure of the brain.

Images were photographed from the viewer with a Polaroid camera. A window level of 20 and a window width of 40 EMI units were chosen to provide optimal contrast resolution. After scanning, each specimen was removed from the container, then sliced with a Hobart electric slicer at levels corresponding exactly to the CT images. The cut surface of the brain was photographed with a Leica MDa Fotocar camera, a 50-mm lens, and Ektachrome film. Photographs of the sectioned brain and their corresponding CT images were enlarged to the same size and oriented exactly with respect to one another. Anatomic structures identified in the CT image were labeled.

Few artifacts were apparent in these images. Air that had not been completely eliminated from a ventricle produced a characteristic zone of low attenuation numbers with a surrounding rim of high attenuation numbers. Brain compressed by the container produced an area of increased density adjacent to the container and obscured superficial structures. These artifacts are pointed out to the reader in the text.

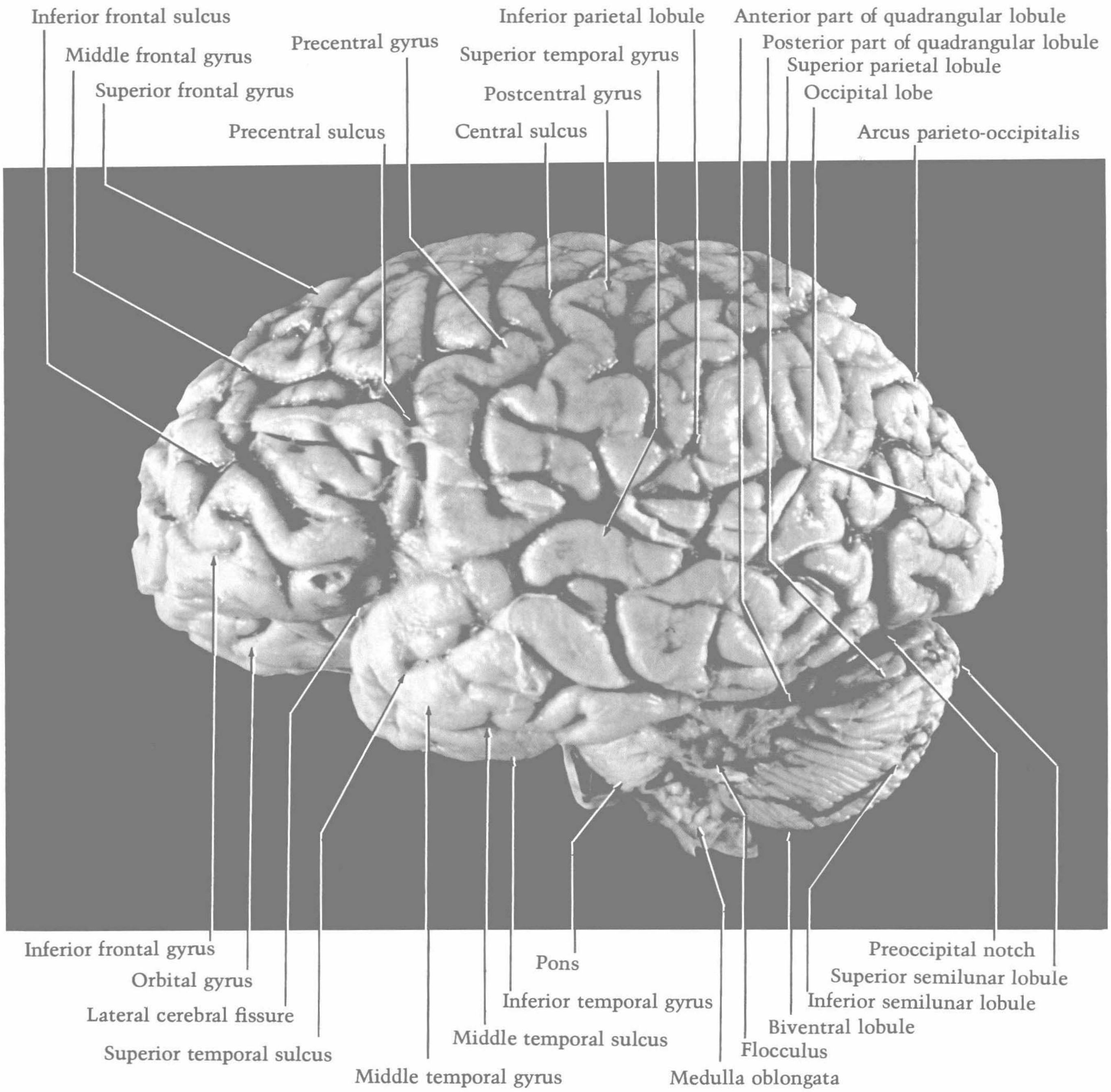
Fresh brain specimens were used for the comparison of brain images obtained on different CT scanners. The preparation of these specimens for scanning was the same as for formalin-fixed brains except that the fresh specimens were submerged in a 0.9% saline bath instead of water to prevent cellular lysis. The cone-shaped polyethylene container was easily mounted in air path scanners in the projection desired. Bolus material was packed around the container in those scanners requiring it.

*Crisp-it, Tupperware Company, Ft. Lauderdale, Florida

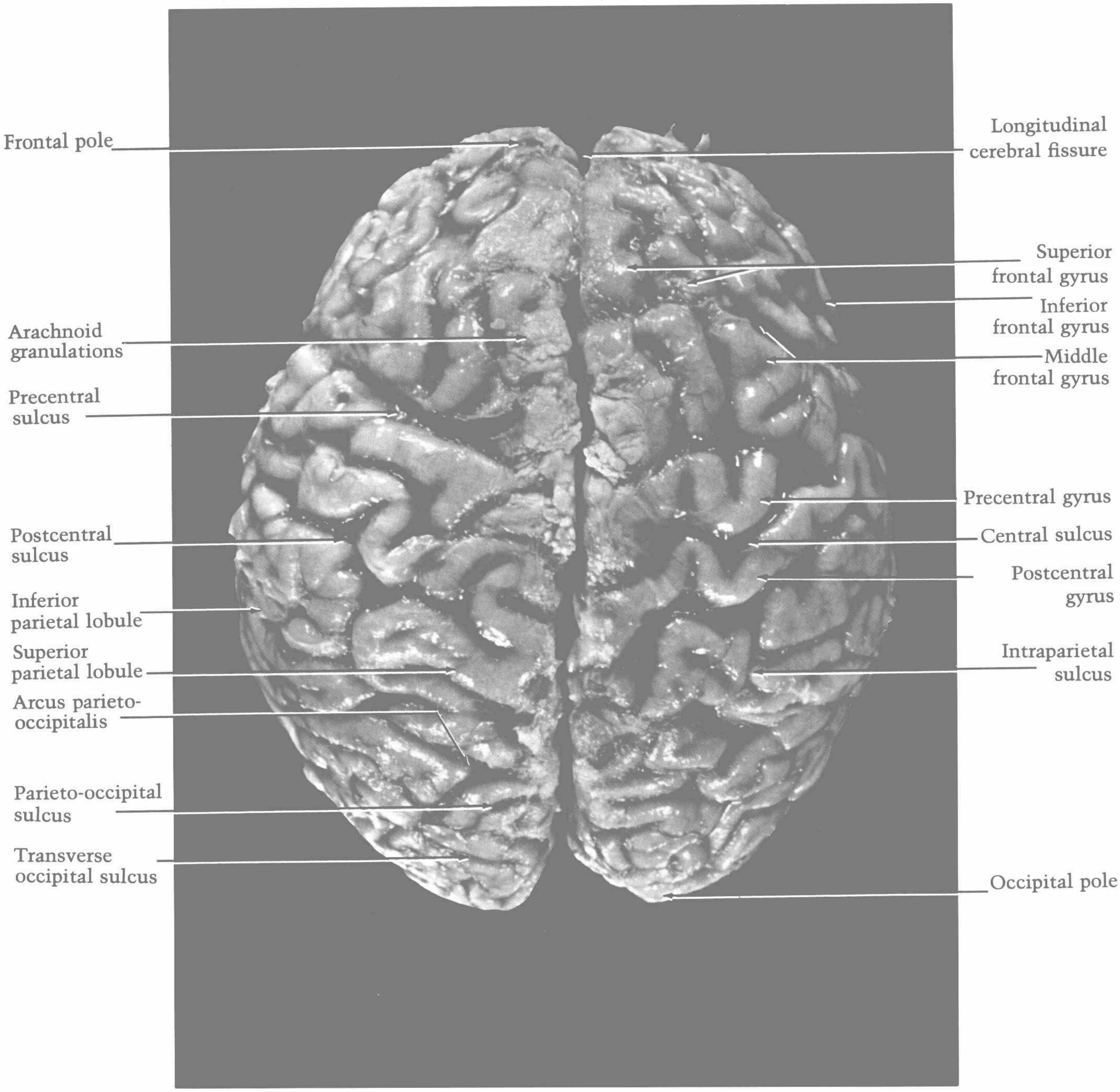
Chapter 2

Surface Anatomy

Lateral Surface



The left side of the brain was photographed. The central sulcus separates the frontal and parietal lobes. A line drawn vertically from the preoccipital notch demarcates the temporal and parietal from the occipital lobes.



The central sulcus is an important landmark because it separates the frontal and parietal lobes. The occipital lobe lies posterior to the parieto-occipital sulcus. Note the asymmetry of the sulci and gyri between the left and right cerebral hemispheres—a normal finding.