The Reliability of Reconstructed Ventricular Landmarks for Localization of Depth Electrodes in Man

E. S. Flamm, M.D.,* and J. M. Van Buren, M.D.

Branch of Surgical Neurology, National Institute of Neurological Diseases and Blindness, National Institute of Health, Public Health Service, United States Department of Health, Education and Welfare, Bethesda, Maryland

The adequate localization of instruments and electrodes inserted in the human brain concerns both the surgeon and the physiologist. Due to the difficulties attending direct comparisons between the predicted and actual anatomical placements in man, there is little statistical information on any particular technique for localization.

It is generally accepted that the most reliable landmarks for localization are intracerebral (e.g., anterior and posterior commissures and the midline of the 3rd ventricle). Radio-opaque oils provide the clearest outlines of these structures but should probably be avoided because of their slow resorption and irritative nature.\(^2\)\(^,\)\(^3\) Gas contrast seems the safest and most practical method but permits only transient visualization. Thus a means which utilizes the original pneumoencephalogram to reconstruct the position of the commissures and ventricular midline on later plain films, as demonstrated by Mundinger and Riechert,\(^6\) is of much interest.

**Method**

Three views of the pneumoencephalogram (6 ft target-film distance) are used for localization: 1. an erect lateral immediately after the lumbar subarachnoid injection of air with the head flexed to show the posterior commissure; 2. an erect antero-posterior view immediately after a second injection of air to show the midline of the 3rd ventricle; 3. a lateral hanging head film with the patient supine to show the anterior commissure (occasionally the posterior commissure is demonstrated on the same view). A centimeter rule on a plane at right angles to the x-ray trajectory at the mid-point of the skull allows correction of magnification.\(^19\)

Transfer of commissural landmarks on the lateral films is carried out as follows. Two points are selected on the base of the skull, one on the planum sphenoidale at a point halfway to its intersection with the anterior outlines of the temporal fossae, and the other an arbitrarily-chosen, well-defined bony irregularity in the vicinity of the base of the dorsum sellae (Fig. 1). With these points forming the base, 2 triangles

FIG. 1. Method of relating the anterior and posterior commissures to basal bony landmarks. On the lateral view, point 1 lies on planum sphenoidale between outlines of temporal fossae. Point 2 is a well-defined bony irregularity near dorsum sellae. These form the base from which triangles may be erected (indicated in dashed and dotted lines). a, b and c refer to distances measured (see text); d is the AC–PC line. On the AP view the midline of the 3rd ventricle is related to its distance from the lateral aspects of the temporal fossae.
Fig. 2. Effects of skull rotation upon the relation of the anterior (●) and posterior (○) commissures to the commissures reconstructed from a true lateral and antero-posterior view by method given in Fig. 1 and text. The reconstructed commissures at the intersection of the perpendiculars and the AC-PC line are shown by broken lines. The arrow indicates the direction of movement of the side of the skull toward the x-ray tube. On the antero-posterior view the midskull is shown by the center line reconstructed in relation to the lateral aspects of the temporal fossae. The horizontal broken line parallel to the orbital roofs is assumed to be parallel to the horizontal axis of the brain. The degrees of skull rotation are approximate.

are erected with their apices at the anterior and posterior commissures. When transferring these commissural landmarks to later films, differences in magnification are judged either by external scales or by distances between distinctive landmarks on the skull itself. After adjusting proportional dividers for any difference in magnification, the commissures are reconstructed. In the antero-posterior roentgenograms, the midline of the 3rd ventricle is related to the external surface of the temporal squamae along a line parallel to the orbital roofs, which is accepted arbitrarily as being parallel to the horizontal plane of the brain.

The validity of the method was determined by the accuracy with which the anterior commissure-posterior commissure (AC-PC) line and the middle of the 3rd ventricle could be reconstructed. To investigate this we selected a group of patients who had 2 stereotaxic pneumoencephalograms performed. On the first pneumoencephalogram the commissures and the middle of the 3rd ventricle were noted and their relation to the bony landmarks established. On the second study the ventricular landmarks were constructed from the bony reference points. Since both commissures and mid-third ventricle were visualized on the second study, their actual position could be directly compared with their reconstructed position.

The 14 patients in the group ranged from 8 to 67 years of age; 9 were males and 5 were females. Eight patients had paralysis agitans, 4 had dystonia musculorum deformans and 2 had choreo-athetosis dating from birth. The interval between the 2 pneumoencephalograms ranged from 6 days to 52 months with a mean interval of 12 months.

A second study (Fig. 2) was made of the commissural displacements introduced by angulation of the skull. To do this, 2 wires were fastened to the base of a dried skull with the ends projecting upward and terminating in the approximate position of the anterior and posterior commissures. For individual identification where overlap occurred on sagittal views, the anterior wire was tipped with a small lead shot. After obtaining true lateral and antero-posterior views of the skull at a 6 foot target-film distance, varying degrees of angulation were introduced.

Results

This method entails the algebraic summation of a variety of possible errors including malposition of the patient and central x-ray beam, faulty estimation of magnification,