Intraoperative transdural functional mapping

Technical note

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During craniotomy for supratentorial intraparenchymal space-occupying lesions, with the patient either under general anesthesia or awake, a smaller durotomy designed to expose only the region of resection may be desirable because of brain swelling. Similarly, during repeat craniotomy or craniotomy following cerebral injury or infection, pial-dural adhesions increase the risk of damage to essential cortex, making a limited dural opening desirable. Intraoperative transdural somatosensory evoked potentials and transdural cortical stimulation mapping permit localization of functional cortex prior to durotomy. These techniques can be combined with intraoperative transdural ultrasonography to identify topographical landmarks and borders of mass lesions.

KEY WORDS • brain mapping • brain neoplasm • cortical stimulation • language cortex • motor cortex • somatosensory evoked potentials

Intraoperative cortical mapping, using either electrical stimulation or somatosensory evoked potentials (SSEP’s), permits safer and more extensive cortical resections in the vicinity of essential cortex. Functional mapping can help identify Rolandic cortex, descending subcortical motor fibers, lateral, basal, and insular (DL Sibergeld, unpublished data) language areas, and the supplementary motor area. However, a small durotomy may be desirable when significant cerebral swelling is present, especially in the awake patient when hyperventilation and significant dehydration are not possible. Similarly, previous surgery or cortical injury may induce the formation of pial-dural adhesions, making durotomy more hazardous. In order to design a durotomy to expose only the area to be resected, the neurosurgeon must be able to delineate tumor borders, local topography, and functional cortex prior to durotomy.

Extraoperative epidural cortical mapping and electrocorticography techniques have been reported previously. The intraoperative use of these techniques, especially in the awake patient, requires technical modifications. These modifications are presented and discussed.

Extradural Mapping Techniques

Following craniotomy, intraoperative transdural ultrasonography is used to define underlying anatomical landmarks, such as sulcal anatomy, that are useful once the dura has been opened. If a structural lesion is present, the borders are delineated in the same manner. Transdural SSEP’s can then be recorded by using a grid system as previously described, thus permitting relatively quick localization of somatosensory cortex in a large operative field.

To avoid pain during transdural electrocortical stimulation in the awake patient, an intradural block (0.25% Marcaine (bupivacaine), 1% lidocaine, 1:200,000 epinephrine, using a short No. 30 needle) must be performed next to the middle meningeal artery as proximally as possible, since approximately 50% of patients experience pain with manipulation of the dura in this region. If transdural language mapping of the temporal lobe is to be performed, an intradural anesthetic block should be placed as low as possible along the middle cranial fossa dura. This can be accomplished by soaking a cottonoid strip in local anesthetic mixture (as detailed above) and placing it along the temporal dura at the base of the craniotomy.

Bipolar constant current stimulation (biphasic 1-msec pulses at 60 Hz, applied for 3 to 4 seconds) is used for transdural electrocortical stimulation of motor cortex. This stimulation technique typically requires two to three times the current needed for direct cortical stimulation. It is not unusual to need 9 to 10 mA to...
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FIG. 1. A: Intraoperative photograph showing the craniotomy performed in a patient with significant cerebral swelling due to a cerebral metastasis from lung cancer and the extradural grid (numbered 1 to 24) used for somatosensory evoked potential (SSEP) localization of somatosensory cortex (lettered G, F, and E). With transdural electrocortical stimulation (TES), leg movements (sites lettered A and B) and arm movements (sites lettered C and D) were elicited. Knowing these sites, the neurosurgeon can determine the position of the central sulcus (white line at white arrow).

B: Following craniotomy, the grid was positioned on the swollen brain, and the location of the central sulcus (underlying the thread indicated by the white arrow) and corresponding rolandic cortex were determined using the transdural SSEP and TES data (somatosensory cortex is lettered G, F, and E; leg movements are denoted by A and B, and arm movements by C and D).

elicit a response from rolandic cortex or to block language function, even in the awake patient.

Following durotomy, the location of essential cortex is identified by positioning the grid on the surface of the brain in the precise location that it occupied extradurally (Figs. 1B, 2, and 3). Alternatively, topographical landmarks identified with intraoperative transdural ultrasound studies can be utilized to translate the epidural map onto the cortical surface. It is often helpful to repeat the ultrasound studies to correlate anatomy and/or lesion location with the epidural functional maps. If essential cortex is within 1.5 to 2.0 cm of the planned resection, it is safest to perform periodic stimulation mapping during the resection.¹

Discussion

Clinical circumstances arise that necessitate a focused durotomy. These situations may involve significant cerebral swelling associated with mass lesions, or pial-dural adhesions from previous surgery, or brain injury from either trauma, previous surgery, or infection. Recording intraoperative extradural SSEP’s in combination with transdural electrocortical stimulation can be used to identify regions of essential functional cortex. Intraoperative ultrasonography can then be used to delineate lesion anatomy and local topography. Armed with this information, the neurosurgeon can design a focused durotomy to expose only the area of brain or lesion to be resected.

Intraoperative use of these transdural mapping techniques requires a number of technical modifications. To prevent pain in the awake patient, it is important to infiltrate the basal dura with intradural local anes-

FIG. 2. Intraoperative photograph following transdural stimulation mapping showing the precentral gyrus (white line with arrowheads), cortical locations where movements were elicited with stimulation (white targeted circles), and the previous durotomy (arrowheads). In this patient, repeat craniotomy for persistent medically intractable frontal lobe seizures with extensive pial-dural adhesions necessitated a smaller durotomy to prevent injury to motor cortex. The previous resection extended from the frontal pole to the premotor gyrus. Extraoperative epidural monitoring localized the epileptic focus to the premotor gyrus.

FIG. 3. Schematic drawing illustrating the two durotomies in the patient depicted in Fig. 2. The first durotomy is indicated by the dashed line and the second by the dotted line. The precentral sulcus and the motor cortex are shown by the shaded area. The premotor gyrus was resected without neurological complication, and the patient has been seizure-free for more than 2 years.
thesia. Furthermore, the current levels required for transdural bipolar stimulation mapping are significantly higher than those needed for direct stimulation of the cortical surface. Translation of the epidural functional map onto the cortical surface can be accomplished with a grid system 2 or with topographical landmarks.

To be certain that a region of cortex is not essential for a specific function, the neurosurgeon must identify the separate cortical region that is essential for that function; the absence of a response to electrical stimulation may indicate too low a stimulus strength, inadequate reversal of paralysis, altered cortical response due to younger patient age, or damage by a structural lesion. 8 Although the technique described permits a smaller dural opening, a craniotomy sufficient to expose the dura overlying potential functional cortex must still be performed.

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References


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