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Intraoperative Ultrasonography Through a Burr-Hole

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Summary

Intraoperative ultrasound diagnosis through a burr-hole was performed in 22 cases using a 5 MHz electronic sector-scanning transducer. The pathology along with the landmarks, such as ventricles and the interhemispheric fissure, were visualized. In two cases, a second burr-hole was placed nearby, and aspiration of the fluid was accomplished under real-time ultrasonic monitoring using the first hole as an acoustic window. Our results suggest a possibility of ultrasound-guided stereotactic surgery of the brain through twin burr-holes.

Keywords: Intraoperative ultrasound; burr-hole; stereotactic techniques; echoencephalography.

Introduction

Since the revival of intraoperative ultrasonography using a real-time high-resolution apparatus[5, 11], ultrasound diagnosis has been successfully used in guiding needles for puncture of the ventricles and puncture/biopsy of intracranial lesions[1–14]. However, it has been mostly performed either through a craniotomy or a trephine opening. If the potential for imaging through a simple burr-hole is developed, the benefits of ultrasonography may be extended even further[8]. We have been successful in obtaining ultrasound images through a burr-hole using a small electronic sector transducer.

Methods and Material

Imaging was obtained through a burr-hole in 22 cases using a ultrasonograph with a 5 MHz electronic sector-scanning transducer* (Fig. 1). The transducer tip was relatively flat and square, measuring 17.8 × 19.6 mm. The transducer, sterilizable either in formalin gas or in Detergicide**, gave a 90 degree, 20 cm deep sector with double focal lengths at 4 and 6 cm. The breadth of the sector was approximately 3 mm at 6 cm. A needle-guide apparatus with a fixed needling angle was an option (Fig. 1). A guideline showing the extension of the needle channel could be superimposed on the monitor cathode-ray tube (CRT) screen with a dotted line.

The burr-hole was conically enlarged using a Cushing 20 mm burr until the diameters measured approximately 12 mm at the bottom and 18 mm at the surface. If the burr-hole was situated horizontally, normal saline was used to fill the gap between the transducer tip and the dura mater for acoustic coupling. Otherwise, a sterile echo-jelly*** was employed.

In two cases, two burr-holes were placed side by side and ultrasound-guided puncture/biopsy was accomplished. We designed an extra-long 18-gauge ventricular needle for puncture and aspiration.

The real-time images thus obtained were observed through monitor CRT screens and recorded on Polaroid**** films and/or videotapes.

Results

In every case examined, ultrasound images of the ventricles and the falx/interhemispheric fissure were obtained. The intracranial pathology was visualized in 20 of the 22 cases. They were 8 neoplasms, 3 intracerebral clots due to various causes, 6 chronic subdural haematomas (Fig. 2), 1 brain abscess, 1 hydrocephalus, and 1 epidural haematoma. The two cases in which visualization was not obtained were a berry aneurysm and an intra-cavernous sinus tumour which was situated lateral to the sector. The quality of the images was fair, but was not as sharp as images obtained through direct contact of the transducer with the dura mater or brain surface. Blurring of the images at the bilateral corner angles was noticed. Tilting of the

* U-sonic Model RT 3000 ultrasonograph and Model V transducer, manufactured by Yokogawa Medical Systems, Musashino-shi, Tokyo, Japan.

** Detergicide, manufactured by USCI, Billerica, Mass., U.S.A.

*** Ultraphonic, manufactured by Pharmaceutical Innovations, Newark, N.J., U.S.A.

**** Polaroid, manufactured by Polaroid Corporation, Cambridge, Mass., U.S.A.

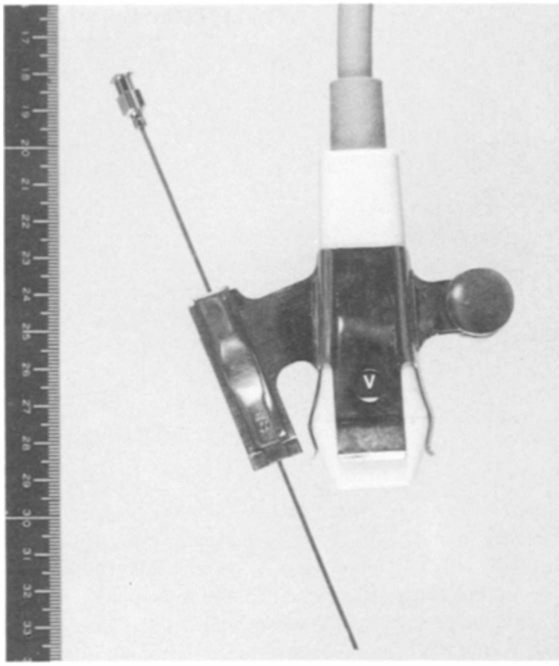


Fig. 1. 5 MHz sector-scanning ultrasonic transducer attached with a needle-guide apparatus which accommodates an extra-long 18-gauge ventricular needle. Size of the head measures 17.8 × 19.6 mm. The needling angle is fixed and corresponds to a guideline superimposed on the monitor cathode-ray tube screen

transducer had a deleterious effect on the image due to loss of contact with the coupling agent.

Ventricular tapping and/or catheterization was easily performed through the hole in two cases after the transducer was removed.

In a case of cystic glioma, the cyst was evacuated by needling through a burr-hole under ultrasonic guidance using another burr-hole as an acoustic window (Fig. 3). The transducer and the needle were manually controlled.

In a case of brain abscess, ultrasound through a burr-hole showed the abscess wall and the guideline passing through the lesion. Another burr-hole was placed exactly along the guideline, and the pus was aspirated using a needle passing through the needle-guide (Fig. 4). This time, alignment was maintained without difficulty. The needle tip position was adjusted accordingly with the gradual shrinkage of the cavity.

In a case of ventricular glioma, ultrasound-guided biopsy of the tumour using two burr-holes and the needle-guide apparatus was attempted but failed because the transducer could not be tilted enough to make the guideline coincide with the tumour. Replacement of the burr-holes by a small craniotomy resolved the problem (Fig. 5).

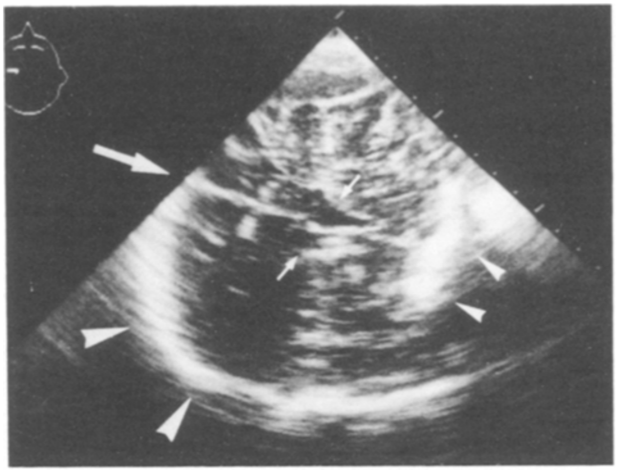


Fig. 2. Coronal-cut ultrasonograph through a left frontal burr-hole in a case of chronic subdural haematoma showing the thick subdural space. The interhemispheric fissure (*arrow*), ventricles (*small arrows*), skull convexity (*arrowheads*), and skull base (*small arrowheads*) are seen. The dots along the right margin of the sector in this and the following figures indicate 1-cm intervals

Discussion

Although intraoperative ultrasonography has become increasingly popular and ultrasound-guided puncture/biopsy through craniotomy has been frequently performed[1, 3–14], the use of ultrasound through a burr-hole has seldom been reported[2, 6], probably because of technical difficulties. The heads of the presently available ultrasound transducers are generally larger than the diameter of the burr-holes and, when applied, generate only images of poor quality[3, 8].

Rubin and associates[9, 10] compromised by placing a trephine opening adjacent to the burr-hole to puncture the target under ultrasound guidance. Enzmann and associates[2] reported a case of successful biopsy through a single burr-hole for alternative ultrasonography and needle biopsy. Using an electronic sector scanner which was built for cardiac purposes, we had been occasionally able to visualize intracranial structures through a burr-hole, and in a case of ventricular glioma we had successfully biopsied the tumour using twin burr-holes[6].

Since the introduction of the present machine, the adoption of routine enlargement of the burr-hole, and the use of a sterile echo-jelly as the coupling agent, intracranial imaging through burr-holes has become a reliable procedure. It has been further facilitated by the use of the needle-guide apparatus and the guideline. However, the fixed needling angle, a fail-safe design for use in craniotomy, precluded the possibility of steering

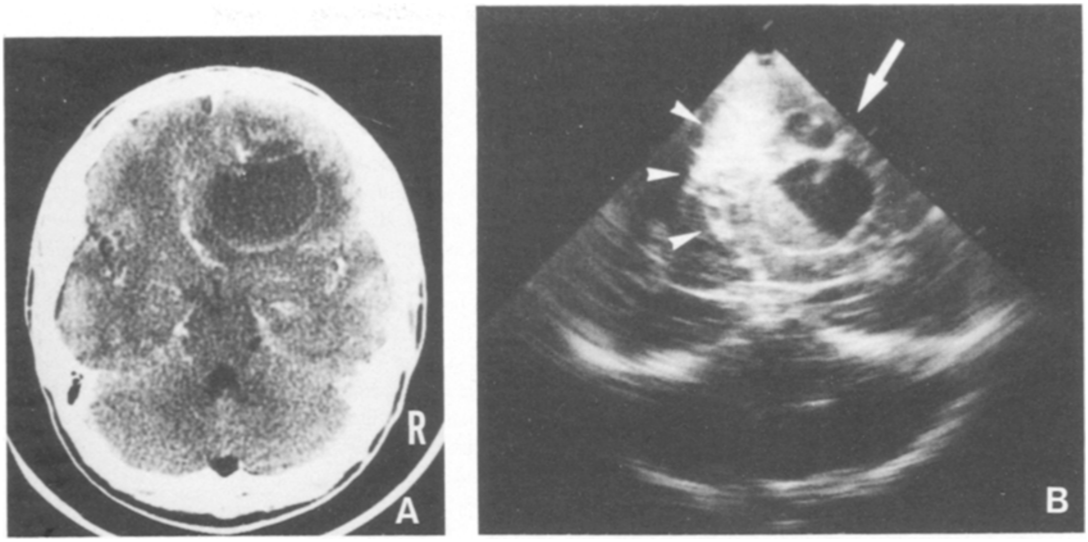


Fig. 3. 48-year-old male with a cystic oligondendroglioma. (A) Enhanced computed tomography (CT) scan shows a cystic tumour with calcifications in the right frontal lobe and bowing of the interhemispheric fissure. (B) Half-coronal ultrasonograph through a mid-frontal burr-hole shows the multi-cystic tumour and the deviated interhemispheric fissure (*arrowheads*). The cyst is aspirated using a needle (*arrow*) manually inserted through another burr-hole. Note a fluid-fluid level in the cyst. The precipitated portion of the cyst was found to be a dark-red bloody fluid, indicating that a spontaneous haemorrhage had occurred sometime between CT scanning and surgery

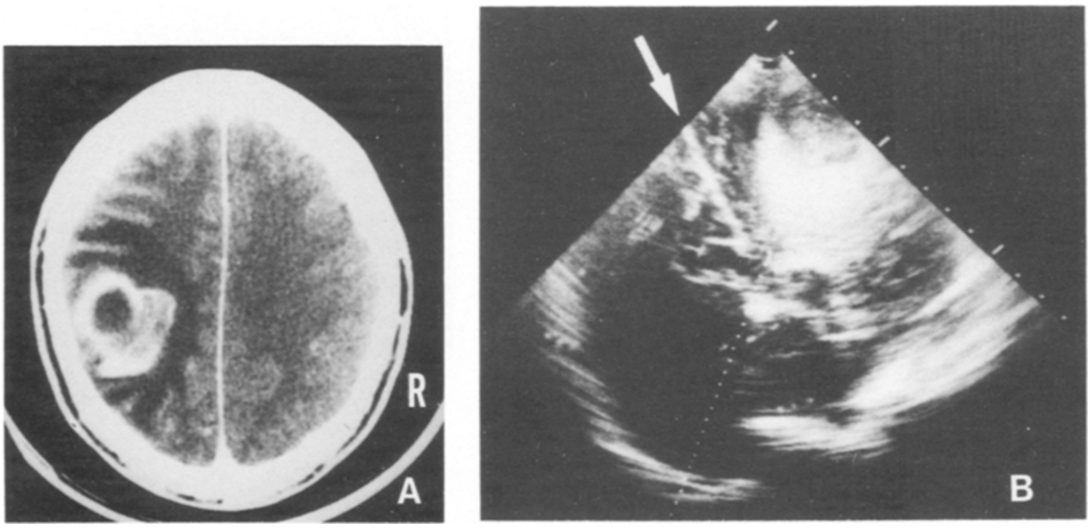


Fig. 4. 49-year-old male with a brain abscess. (A) Enhanced computed tomography scan shows a ring enhancement with medial bulging. (B) Coronal-cut ultrasonograph through a parietal burr-hole shows a cystic mass. The dotted guideline is set to pass through the second burr-hole as well as through the target. Pus is then aspirated using a ventricular needle passing through the needle-guide. *Arrow* indicates interhemispheric fissure

of the needle to aim at the target. A needle-guide with an adjustable needling angle is required.

In recently reported computed tomography (CT) guided biopsies, only a twist drill or a small burr-hole has been sufficient. However, the procedure usually occupies the CT scanner for a considerable length of time. The introduction of the needle itself is performed blind, and adverse effects of the biopsy procedure, such as haemorrhage, cannot be evaluated under real-time creating the possibility of a delay in treating such changes[14]. On the other hand, ultrasound is easy to handle and offers a Surgeon's eye view of the intra-cranial structures. To monitor or to actually view the passage of the needle, however, at least two burr-holes are necessary. Ultrasound images are prone to be obscured by various artifacts such as the near-field

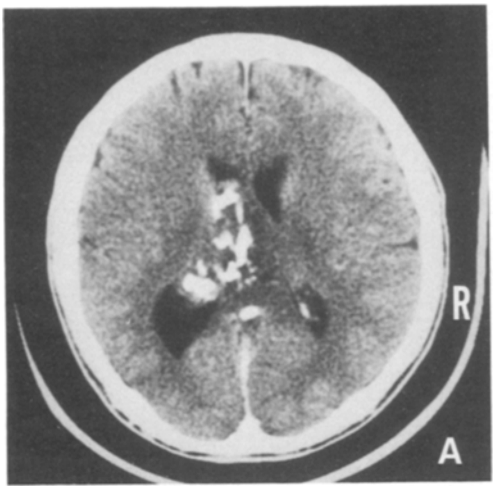
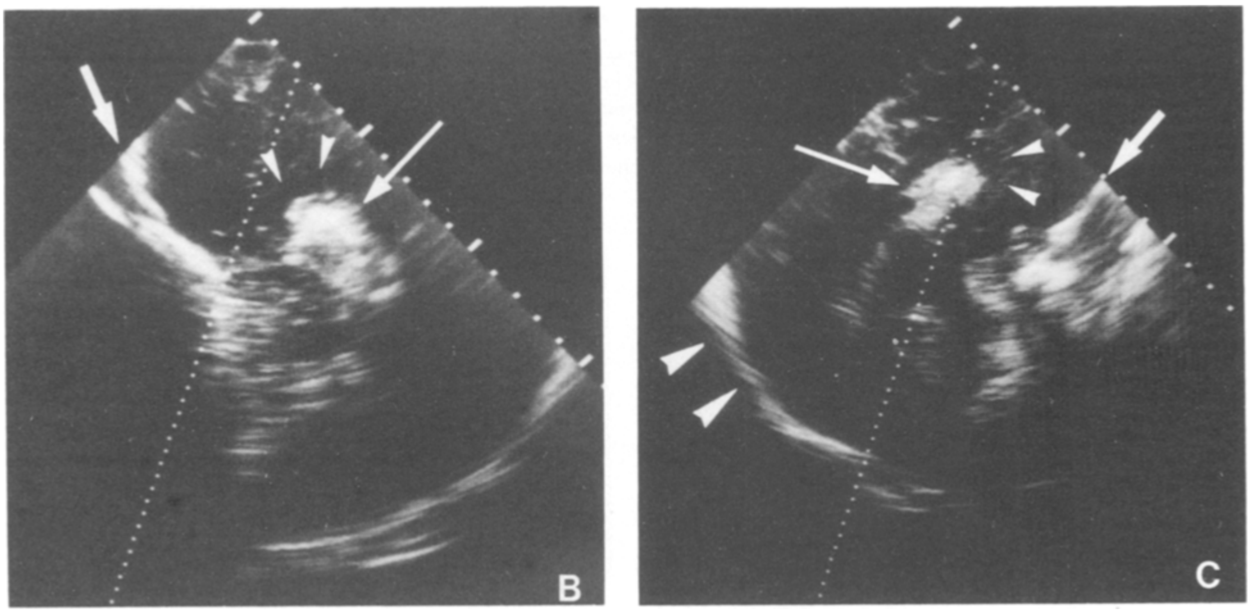


Fig. 5. 30-year-old male with an intraventricular oligodendroglioma. (A) Preoperative enhanced computed tomography scan. An intraventricular tumour with irregular calcification is shown. (B) Sagittal-cut ultrasonic image through a burr-hole shows the tumour. Front of head is on the left side of the image. The transducer could not be tilted enough for the dotted guideline to coincide with the tumour (*thin arrow*). The anterior horn (*small arrowheads*) and the frontal skull base (*arrow*) are seen. (C) Sagittal-cut ultrasonograph through a small craniotomy shows the guideline passing through the tumour (*thin arrow*). Front of head is on the right side of the image. The biopsy through the needle-guide established the diagnosis of oligodendroglioma. Frontal skull base (*arrow*), occipital skull convexity (*arrowheads*), and the anterior horn (*small arrowheads*) are seen



artifact[2, 8, 10] and the reverberation artifact[14]. For lesions such as tumours, haemorrhages, and cysts, which stand out as either echogenic or anechoic areas, ultrasound-guided stereotactic aspiration, biopsy, and/or catheterization would be much more convenient.

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