The use of waterjet dissection in endoscopic neurosurgery

Technical note

JOACHIM OERTEL, M.D., PH.D., MICHAEL GEN, M.D., JOACHIM K. KRAUSS, M.D., MATTHIAS ZUMKELLER, M.D., PH.D., AND MICHAEL R. GAAB, M.D., PH.D.

Department of Neurosurgery, Hannover Nordstadt Hospital, Hannover; Department of Neurosurgery, Hannover Medical School, Hannover; and Department of Neurosurgery, Klinikum Minden, Germany

Waterjet dissection enables vessel preservation and a reduction in intraoperative blood loss. Because even minimal bleeding should be avoided during neuroendoscopy, the waterjet device may be a particularly valuable tool in such procedures. The authors used this instrument in experimental endoscopic procedures in 20 cadaveric porcine brains and clinically in four patients with obstructive hydrocephalus. A precise and accurate septostomy was achieved in all of the pig brains. In two patients the hydrocephalus was due to intraventricular hemorrhage, in one a posterior fossa tumor, and in one a cystic craniopharyngioma. In all patients the surgical view was kept clear with waterjet irrigation and suction. Using a pressure setting of 10 bars, the waterjet device successfully perforated the cyst wall of the craniopharyngioma in one patient and the floor of the third ventricle in three patients. The use of the waterjet device in selected endoscopic procedures appears safe, and may help reduce intraoperative bleeding. However, further studies are needed to confirm the utility of the waterjet tool in endoscopy.

KEY WORDS • waterjet dissector • neuroendoscopy • ventriculostomy • septostomy • pig

In neurosurgery, the use of the waterjet device for tissue dissection and vessel preservation is a matter currently under intense discussion. The device has demonstrated reliable blood vessel preservation, which results in a reduction in intraoperative blood loss compared with conventional techniques such as ultrasonic aspiration. This feature could be of tremendous value in neuroendoscopic procedures, during which even minimal bleeding can be disastrous. Because traumatic aneurysms and fatal subarachnoid hemorrhages have been noted after endoscopic procedures, vessel preservation is extremely important. With this objective in mind, the adaptation of the waterjet device to endoscopic use may offer distinct advantages over more conventional techniques.

Materials and Methods

Study Design

In the present study, a handpiece designed to adapt waterjet technology to neuroendoscopic use was tested in 20 cadaveric porcine brains and in four patients. The adapted waterjet system was evaluated for aspiration quality and intraoperative visibility. The quality of the dissection under endoscopic visualization was tested by cutting into the septum pellucidum in 10 porcine brains and the lateral ventricle wall in another 10. Dissection quality was also examined at the floor of the third ventricle in three patients with obstructive hydrocephalus and at the cyst membrane in one patient with a craniopharyngioma.

WaterJet System and Endoscopic Equipment

For a detailed description of the waterjet instrument, please refer to earlier reports. The device has been approved for surgical use in most European countries, including Germany, as well as in the US. All procedures were performed using the Gaab universal neuroendoscopic system (Karl Storz GmbH & Co., Tuttingen, Germany) developed by the senior author (M.R.G.), and a 0° rigid rod-lens Hopkins endoscope with the standard operating sheath. A new waterjet handpiece was specially designed for use with the Gaab neuronavigation system. This device consisted of a 120-μm nozzle emitting a helically turned jet of water, and was fitted with an integrated surrounding suction tube (Fig. 1).

Endoscopic Waterjet Application in Pigs

The new handpiece was used to dissect the lateral ventricle wall in 10 fresh unfixed cadaveric pig brains with isotonic saline solution at 37°C. The waterjet device was tested at pressures of 5 and 10 bars to determine the optimal...
pressure for cutting under endoscopy. After each procedure, we examined the resected tissue under low magnification to measure the cutting depth. In another 10 fresh unfixed cadaveric pig brains, an endoscopic septostomy was performed using the handpiece. Without using any mechanical force, the tip of the waterjet handpiece was placed in direct contact with the septum pellucidum at a pressure of 10 bars for 5 seconds. After perforation of the septum, the opening was enlarged with a standard Fogarty balloon catheter and the contralateral ventricle was inspected via the perforation. The accuracy and reliability of septum perforation, problems with visibility, the need for suction, and any other difficulties encountered were noted immediately after each procedure.

Endoscopic Waterjet Application in Patients

The waterjet device was applied endoscopically in four patients suffering from obstructive hydrocephalus. In two of these patients IVH was causing blockage of the aqueduct, and in one the cause was a cerebellar tumor. In the fourth patient, a cystic craniopharyngioma was obstructing the Monro foramen. All procedures were performed with the patient supine and after induction of general anesthesia, with the head fixed in slight anteflexion in a three-pin headholder device. After undertaking a standard approach to the lateral ventricle with the endoscopic sheath, the trocar was removed and the 0° working optic lens was inserted. In the patient with the craniopharyngioma, the cyst wall was coagulated and the waterjet device used for perforation and fluid suction. The capsule was then removed with grasping forceps.

In the patients with IVH-related hydrocephalus, the operating sheath was carefully advanced through the Monro foramen under direct view, and the hematoma blocking the approach to the floor of the third ventricle was sucked away. After suctioning, the ideal point for perforating the floor of the third ventricle was identified at the midline between the mammillary bodies and the infundibular recess, and the waterjet device was applied. The ventriculostomy site was then enlarged by inflation of a Fogarty balloon catheter. The procedure was finished in the standard fashion after inspection of the basal cisterns.

Results

Experimental Application

A reliable and accurate dissection of the ventricle wall was consistently achieved in the porcine brain with the new handpiece. A close correlation between waterjet pressure and dissection depth was found. With suction, the dissection depth was 0.86 mm under 5 bars and 2.39 mm at 10 bars of pressure, whereas without suction the dissection depth reached 1.63 mm at 5 bars and 3.28 mm at 10 bars (Fig. 2). A precise and accurate endoscopic septostomy was achieved in all cases with 10 bars of pressure (Fig. 3) and a Fogarty balloon catheter was used to enlarge the opening without difficulty. The best results for septum perforation with only minor water disturbance were achieved when the nozzle tip was placed in direct contact with the tissue without mechanical force or additional suction. If additional suction was used, or the nozzle tip was held at a distance from the target tissue, turbulence was produced that obscured the endoscopic view of the surgical field.

Clinical Application

In all clinical cases, the surgical view was kept clear with waterjet irrigation and suction. For evacuation of the hematoma and the cyst fluid, continuous suction was applied at 500 mbars. The cyst wall of the craniopharyngioma was pierced easily at a pressure of 8 bars, but the floor of the third ventricle was more resistant to dissection. In one patient, 8 bars was sufficient to perforate the ventricle floor, but in the other two 10 bars was required (Fig. 4). During perforation of the ventricle floor, no suction was applied.
Neuroendoscopic application of the waterjet device appears to be a viable option. Cystic fluid and intraventricular hematomas can be effectively sucked out using the instrument. In our experience, a reliable perforation of the cyst wall and third ventricle floor can be achieved using pressures low enough that the nearby blood vessels are preserved. The use of the waterjet device is a safe and successful technique for selected endoscopic procedures. Whether this device will consistently achieve superior clinical results is the focus of ongoing research. We recommend that the utility of this device in neuroendoscopic tumor removal procedures also be evaluated.

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Address reprint request to: Joachim Oertel, M.D., Ph.D., Department of Neurosurgery, Nordstadtkrankenhaus, Klinikum Hannover, Haltenhoffstrasse 41, 30167 Hannover, Germany. email: oertelj@freenet.de.