Integration of Ultrasonography and Endoscopy Into Transsphenoidal Surgery With a “Picture-in-Picture” Viewing System

—Technical Note—

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Abstract

A technique to integrate ultrasonography and endoscopy is described for transsphenoidal surgery to prevent intraoperative internal carotid artery (ICA)-related, life-threatening complications such as aneurysmal formation and carotid-cavernous fistula. The ultrasound unit helps avoid direct injury to the ICA. The technical advantage of this system is the miniature 1-mm diameter microvascular probe, which does not disturb the operative field. An arterial or venous flow source of even an invisible vessel can be detected easily, noninvasively, and reproducibly. Real-time information with a 100% detection rate for the ICA is helpful for predicting localization even in the intracavernous portion, where the ICA is invisible. The endoscope unit can visualize the dead angle areas of the operating microscope by varying the endoscopic gateways and display on a “picture-in-picture” system. The advantage of both devices is the integration with a video processor, so that the real-time information from each unit can be switched intraoperatively onto the display as required. This method is of particular help for removing lesions with intracavernous invasion or encasement of the ICA.

Key words: transsphenoidal surgery, ultrasound, endoscope, complication, vascular injury

Introduction

Various approaches are applied for transsphenoidal surgery, such as the sublabial rhinoseptal, direct transnasal, and endonasal endoscopic approaches, endoscopic sphenoidectomy, and a combined technique using an operating microscope and endoscope. However, all approaches carry the risk of internal carotid artery (ICA)-related complications. There is a higher risk of serious vascular injury in cases of intracavernous invasion or encasement of the ICA. Therefore, intraoperative traumatization of the invisible intracavernous portion of the ICA may occur during transsphenoidal surgery. We have devised an operative system incorporating advanced ultrasonography and endoscopy to help preserve critical vessels such as the invisible portion of the ICA, thus reducing operative morbidity.

Technique

Pulsed-wave Doppler microvascular ultrasonography using a MULTI-DOP T scanner (DWL Elektronische Systeme GmbH, Munich, Germany) with a 1-mm diameter probe (Fig. 1) can detect blood flow within an invisible and critical vessel, particularly the intracavernous portion of the ICA. The Doppler scanner is compatible with a video processor, allowing all recordings to be stored and displayed at any time. Ultrasonography is used intraoperatively to predict the localization of the invisible intracavernous portion of the ICA prior to removal of a lesion within the cavernous sinus. Detection of a venous flow pattern from the lateral aspect of the sellar

Fig. 1 Photograph of the 1-mm diameter microvascular Doppler probe inserted into the holder.
Fig. 2  left: Intraoperative photograph showing placement of the 1-mm diameter microvascular Doppler probe in the sellar region during transsphenoidal surgery. Note that the operative field is not disturbed by positioning the probe.  center: Intraoperative real-time ultrasonograms indicating two different blood flow patterns, which were obtained at depths of 1.2 and 4.5 mm from the wall of the cavernous sinus, suggesting the cavernous sinus (upper) and internal carotid artery (lower) with mean blood flow velocity 22 and 36 mm/sec, and pulsatility index 0.23 and 0.78, respectively. Calibration bar = 1 sec.  right: Endoscopic photograph through a 70-degree lens scope introduced into the left cavernous sinus after removal of an intracavernous lesion, which was out of the field of the operating microscope.

region indicates the proximity of the cavernous sinus and an arterial flow pattern inside the cavernous sinus indicates the intracavernous ICA (Fig. 2). The probe is left in position with its holder, and both the size and depth of the vessel are measured by turning the dial of the Doppler signal gain from initially waning to waning Doppler sounds. Even if the cavernous sinus is not inspected, both the cavernous sinus and ICA can be detected at frequent intervals by positioning the probe appropriately. Therefore, the precise localization of the ICA can be evaluated in real time.

The endoscope unit consists of rigid and steerable endoscopes of 2 and 4 mm in diameter (Codman and Shurtleff, Inc., Raynham, Mass., U.S.A.). The rigid endoscopes have four optic angles, 0, 30, 70, and 120 degrees, at the tip. More recently, the endoscope unit has included another advanced imaging device which allows the endoscopic view on the display to be frozen at any time, and simultaneously visualized with the current view on the same display. The endoscope unit is connected to an advanced operating microscope (OME-8000; Olympus Optical Corporation, Tokyo) which incorporates a “picture-in-picture” viewing system. The operator can view both microscopic and endoscopic images through the optical eyepieces as well as on the same video display. The endoscope unit is also connected to the video processor, so that the intraoperative information from both the ultrasound and endoscope units can be switched at any time, and interpreted rapidly and easily.

Intraoperatively, the endoscope is introduced when the Doppler signal from the cavernous sinus is detected by ultrasonography or when the cavernous sinus is exposed. The endoscopes are adjusted to the desired position using an adaptable articulated arm (holder) fastened to a runner along the operating table. During microsurgery, endoscopy is used exclusively to observe the blind operative fields in the dead angles of the operating microscope. By interchanging the rigid endoscopes, brightly illuminated access can be obtained to multiple aspects of the operative field. The steerable endoscope also aids in viewing operative fields that are not fully observable under the operating microscope. Therefore, the operative blind areas can be effectively inspected by varying the endoscopic gateways.

Discussion

The integration of ultrasonography and endoscopy represents a very modest evolution of the transsphenoidal approach. Ultrasound monitoring helps to supplement the limits of endoscopy, indeed, endoscopic viewing is of little or no use when the video image is blurred. The intraoperative use of pulsed-wave Doppler microvascular ultrasonography enables detection of the ICA which is invisible to the operating microscope easily, accurately, and noninvasively. Real-time guidance allows precise control of the removal of an intracavernous lesion with a
hard consistency, such as meningioma. Further improvement of both units, in particular the endoscopic equipment, is required for the operator to feel more comfortable while viewing the monitor. To further develop our current system, two projects are now in progress: The first is focusing on the possibility of using both ultrasonography and endoscopy technologies simultaneously in the same working space; and the second is focusing on the possible integration of a refined aspiration unit into the endoscope probe, ensuring useful optic control within a narrow operative field.

References


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Commentary on this paper appears on the next page.
Commentary

Ultrasonography has been used before to detect invisible vessels or after aneurysm clipping. It could be a useful technique to detect the ICA in transsphenoidal surgery, especially for pituitary adenomas extending into the cavernous sinus. It could also be used in the removal of meningiomas invading the cavernous sinus, but only in those which are accessible via the transsphenoidal route. True intracavernous meningiomas, and those invading the cavernous sinus from the outside, are impossible to remove by the transsphenoidal route. This combination technique of integrated ultrasonography and endoscopy would be advantageous during the removal of difficult pituitary adenomas, as in general these adenomas do not invade the ICA wall but only encase the artery and so can be dissected safely from the ICA. This technique can aid in this dissection. The picture in picture, although a good method, is still not very useful in practice. The concept of additional image views in the blind zones of the microscope is definitely helpful to the surgeon during the operation. Combination of these new techniques is beneficial, but there are still a few practical problems which are yet to be resolved.

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The authors present an interesting technical variation for use with the transsphenoidal approach, using both ultrasonography and endoscopy simultaneously, in a small craniectomy working space, integrating it with a video processor. The aim is to preserve the invisible portion of the ICA, thus reducing unpredictable damage and complications, related to its intracavernous portion. This monitoring seems useful in supplementing the limits of rigid or steerable endoscopes, when the video image is blurred. It will be difficult to analyze the advantages of this method for those who have not tried it, since it will undoubtedly get in the way of the surgeon in such small craniectomies with little room for manipulations.

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The authors reported the intraoperative use of ultrasonography and endoscopy during transsphenoidal surgery (TSS) chiefly in order to avoid carotid injury. In general, TSS is a very safe and less invasive procedure, but many kinds of complications are known. Most of them are not so serious and controllable except for injury of internal carotid artery (ICA), which may be life-threatening. Zervas reported an international survey showing that the incidence of ICA injury was 0.21% (11 of 5283 patients) and that 4 of 11 patients died. Ciric et al. published the results of a U.S. national survey on complications of TSS, in which ICA injury was found in 1.1% (0.4% in the experienced surgeons group). In our series of 1262 TSSs, we have experienced ICA injury in three patients (0.24%). I think that ultrasonography and/or endoscopy may be useful to avoid this dangerous complication. In addition, better understanding of the regional anatomy and careful preoperative design will certainly reduce the occurrence of most surgical complications.

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The authors have integrated ultrasonography and neuroendoscopy for transsphenoidal operation. The neuroendoscopy unit can visualize the dead angle area of the operative microscope, and the ultrasound monitoring can detect the ICA which is invisible to the microscope, so accurate and real-time guidance allows precise localization of the removal of an intracavernous lesion during transsphenoidal operation. I believe that the transsphenoidal operation with ultrasonography and neuroendoscopy increases the safety of transsphenoidal surgery, particularly when the tumor invades the cavernous sinus and encases the ICA. I hope to see more clinical data when this technique is used in patients in the future.

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