EDITORIAL

Does chiasmatic blood supply dictate endonasal corridors?**Theodore H. Schwartz, MD**

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IN their article, Gu et al.⁹ introduce a seemingly minor but actually quite important nuance to the endonasal endoscopic approach (EEA). To understand the significance of their report, one must first review a bit of the history of transsphenoidal craniopharyngioma surgery. In the decades before the modern “endonasal endoscopic” era, the transsphenoidal route was thought to be safe for removing subdiaphragmatic craniopharyngiomas.⁵ These tumors were anatomically similar to pituitary tumors and well suited for the microscopic transsphenoidal approach. Once the transsphenoidal approach was extended through the tuberculum sellae, the application of the approach became suitable for tumors with supradiaphragmatic extension, although many of these were still mostly subdiaphragmatic and the sella was generally invaded with tumor and enlarged, which facilitated the approach.^{2,14} With the development of the extended EEAs, the transsphenoidal corridor could be used to remove purely supradiaphragmatic tumors above a normal-sized sella.^{3,6,7,10,12} These tumors were often within the confines of the third ventricle, or purely intraventricular, as were the tumors described in this article.

In recent years, several groups have published their experience with removing supradiaphragmatic, third ventricular craniopharyngiomas by using an EEA, and in skilled hands the results are quite good—arguably better than those achievable with a transcranial approach.¹¹ However, the corridor used to remove these tumors, although supradiaphragmatic, is generally infrachiasmatic. The reasons the infrachiasmatic corridor is used are multiple. The tumor generally takes its origin from the pituitary stalk, which is an infrachiasmatic structure. The chiasm is often pushed upward and forward by the tumor, so the endonasal trajectory takes the surgeon under the back of the chiasm

into the third ventricle. Finally, it has been written in the literature that “This route minimizes the risk of postoperative visual loss, which is strictly related to the integrity of the vascularization of the optic chiasm. In fact, at this level, most of the blood supply to the optic system comes from the superior surface, from the branches of the anterior cerebral artery (ACA) and anterior communicating artery (ACoA), thus rendering the inferior approaches less dangerous than the transcranial routes.”⁴ Herein lies the crux of the infrachiasmatic argument—that it is safer due to the origin of the vascular supply to the chiasm, which they presumed arose from above, namely from the ACA and the ACoA. However, as we will show, this presumption is fallacious. Indeed the vascular supply to the chiasm is extremely variable and arises both from above and below the chiasm, but the majority of the blood supply to the central part of the chiasm arises from below, from the ophthalmic portion of the internal carotid artery (ICA), as the ascending branches of the superior hypophyseal artery (SHA) and other small perforators that form a rich anastomotic network of vessels.

Probably the most classic article on the blood supply to the chiasm was written in 1969 by Richard Bergland and Bronson Ray at Cornell–New York Hospital.¹ In this paper, the authors use 480 autopsy specimens and demonstrate that the supply from the ACAs above the chiasm only feeds the lateral chiasm. In contrast, the supply from below, mainly from the SHAs, feeds the midline chiasm. These results supported their claim that the classic bitemporal hemianopia resulting from pituitary tumor growth pushing upward on the chiasm may not be entirely compressive but may also have a vascular origin. Later work by Al Rhoton mostly confirms these original observations, with a few small novel observations. In his article

ACCOMPANYING ARTICLE See pp 1166–1172. DOI: 10.3171/2015.1.JNS132842.**INCLUDE WHEN CITING** Published online February 27, 2015; DOI: 10.3171/2014.6.JNS141129.**DISCLOSURE** Dr. Schwartz owns stock in Visionsense. He is also a consultant for Karl Storz, and receives support for a non-study-related clinical or research effort from the NIH.

with Perlmutter on the ACA-ACoA complex he shows that the A₁ perforators terminate in the chiasm 40% of the time and that the ACoA perforators terminate in the chiasm 21% of the time.¹³ In a subsequent paper with Gibo and Lenkey on the supraclinoid ICA,⁸ he notes again that there is significant variability in the number and origin of the perforators supplying the chiasm from below but clearly demonstrates that the ascending branches of the SHA are significant feeders to the chiasm. However, he also notes that the rich “circumfundibular anastomoses,” fed not only by the SHAs but also by the infundibular arteries (which arise from the posterior communicating artery [PCoA]) and other small perforators off the ICA, provide the blood supply to the central chiasm from below.

Several conclusions can be drawn from these studies. First, if one is using a midline approach to the third ventricle, it is probably safer to open above rather than below the chiasm. Indeed, the translamina terminalis (TLT) approach has been used for years through a craniotomy to reach this location. Why then are the results of endonasal endoscopic surgery, which is generally performed using an infrachiasmatic corridor, so successful at preserving and even improving vision? First, the blood supply to the chiasm from below is clearly redundant. Although it is of utmost importance to attempt to preserve the infrachiasmatic perforating vessels, and these are well visualized and can be preserved using an EEA, it appears to be possible to sacrifice one without compromising vision. Although there is currently little scientific data available to support this claim, it is my experience, and after speaking with other endonasal surgeons about their experience as well, that sacrifice of a small subchiasmatic perforator does not uniformly lead to a decline in vision. Whether this is always or only sometimes the case is unknown. Second, the space between the top of the chiasm and the ACoA is quite limited, and this is the corridor that must be used from below. In contrast, the corridor between the top of the pituitary gland and the bottom of the chiasm is roughly 1 cm, which is more than enough to remove most third ventricular craniopharyngiomas.

This brings us back to the article by Gu et al.⁹ The authors have shown that in certain circumstances, when the anatomy of the tumor dictates, an approach uniquely above the chiasm, or a combined approach both below and above the chiasm, is not only feasible but may be desirable, and can be performed without necessarily causing a decline in vision. In my opinion this approach should be used in only 2 circumstances: 1) if the infrachiasmatic approach is inadequate to reach tumor located above the chiasm, or 2) if the tumor has pushed the chiasm so far downward that the infrachiasmatic corridor is not feasible. In my experience, these circumstances arise rarely and, in general, most tumors can be removed using a purely supradiaphragmatic, infrachiasmatic corridor. I would also add that this article presents its results in a vague manner, stating in one place that there were no anterior or posterior pituitary issues and in another place that 2 patients needed hormone replacement therapy. Likewise, the authors do not report any visual deterioration in the results, but then clearly show that 1 of their patients had a deterioration in vision in 1 eye after surgery.

Nevertheless, the concept presented in this paper is sound and one deserving of more exploration. Further study of the visual deficits arising from sacrifice of single perforators either above or below the chiasm is needed to clarify the issue, and it is likely that the variability in blood supply will make any sort of firm generalization difficult. Although anatomical studies can tell us if a particular vessel terminates in the chiasm, it cannot tell us if sacrifice of this vessel will necessarily result in visual loss, particularly in an abnormal chiasm under longstanding pathological compression.

<http://thejns.org/doi/abs/10.3171/2014.6.JNS141129>

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Response

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We greatly appreciate the thoughtful and scholarly editorial written by Professor Schwartz, who makes extraordinary contributions to endoscopic endonasal skull base surgery. As the leader of one of the most prominent teams for endoscopic endonasal skull base surgery worldwide, his extraordinary research and lectures triggered our interest in the EEA. His editorial emphasized and reiterated the essential concepts of the EEA for the treatment of skull base lesions. The goal during all the steps, from surgical planning through intraoperative manipulation, is to achieve maximal lesion removal while minimally disturbing neurological function. Our article explains that attempts at gross-total resection of tumors should not compromise hypothalamus-pituitary function, visual function, or adjacent major arteries, and this concept was also profoundly illustrated in Professor Schwartz's editorial.

The optic apparatus is inevitably encountered during skull base surgery performed using an EEA to the suprasellar region. It is well known that to protect neural structures, manipulation, which can cause mechanical traction and thermal injury to the tissue, must be minimized, and the relevant blood supply must be preserved as much as possible. For the cases reported in our article the surgical decision making was based on the blood supply of the optic chiasm and its relevant position to neighboring critical neurological structures.

One previous report¹ that described the TLT corridor in an endonasal approach performed using the endoscopy-assisted mode inspired us to use the TLT corridor with the

full EEA. Compared to the endoscopy-assisted approach, no more difficulty would be encountered but a better panoramic view of the surgical field may be gained in a purely endoscopic approach. Fortunately, we succeeded in removing the tumor with an acceptable clinical outcome. It is important to note that the TLT corridor can be used when a stretched lamina terminalis and downward-displaced optic chiasm are present due to compression by the tumor, and the infrachiasmatic space is too limited for removal of the tumor. It can also be used when the tumor presents with great superior extension or remains partially hidden even after being pulled downward.

We aimed to determine the predictors of the clinical outcome of preoperative visual impairment after skull base surgery. Two years ago we used diffusion tensor imaging displayed at a computer workstation to detect the visual pathway in patients who harbored sellar and suprasellar lesions and presented with vision loss. However, the reconstructed images were obscured, and further discrimination of the compressed optic nerves and chiasm was not possible.

Professor Schwartz kindly mentioned the limitations of our study. First, we used the term "partial improvement," the meaning of which was not clear, to describe the outcomes in the *Results* section. Second, we did report pituitary function concentrating on any new deficits, because preoperative pituitary dysfunction varied in degree in the reported cases.

In conclusion, searching for a new operative corridor will improve skull base surgery as long as rational guidelines are not overstepped.

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