

Editorials

Endonasal resection of craniopharyngiomas

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Gardner and colleagues have described their series of 16 patients who underwent an endoscopic, expanded endonasal approach (EEA) for craniopharyngioma between 1999 and 2006. The primary outcomes of their study included the following: endocrine and ophthalmological results, extent of resection, and complications. The majority of their patients underwent planned complete resection. In these patients, 73% (8 of 11) had a gross-total resection without recurrence during a mean follow-up of 34 months. No patient in the series experienced visual worsening. The post-operative rate of permanent diabetes insipidus (DI) was 8%. Cerebrospinal fluid (CSF) leaks were documented in 58% of patients. In 1 patient, a stroke occurred from a perforating vessel from a posterior cerebral artery injury.

Of interest here is the classification of craniopharyngiomas into a system that is best appreciated by the endoscopic, endonasal neurosurgeon: Type I, preinfundibular; Type II, transinfundibular; and Type III, retroinfundibular. In theory, this is an attractive classification system. In practice, however, there will be instances in which the craniopharyngiomas are either too large and the stalk obscured, or the MR images will be inadequate to fully ascertain the location of the tumor with respect to the infundibulum. I would like to commend the authors on their willingness to tackle some of the more difficult types of craniopharyngiomas (for example, the Type IIIa and IIIb lesions) through an EEA. Years ago, I would have thought such an approach to the “retrochiasmatic” craniopharyngioma would have been impossible. Now, with the advent of the techniques that have been uniquely shared by the minimally invasive neurosurgeon and otolaryngologist and which are expounded on in this study, craniopharyngiomas of all types can be the target of EEA.

As with all new techniques that come forward for analysis when compared with established, conventional ones, a critical review of the complications must be undertaken. Here, it is clear that EEA for craniopharyngioma is well tolerated, and the vast majority of patients do well after tumor resection. Endocrine and ophthalmological functions were reasonably well preserved and/or maintained. The one area, of course, where greater strides will need to be taken and where improvements in technique will be mandatory is with the rate of CSF leakage. However, it sounds as though the authors are well on their way to improving their outcomes with CSF leaks by using vascularized mucosal flaps together with local reinforcement of the sellar floor.

This report by Gardner and associates is more than a technical note, but is not yet quite at the level of the larger published series on craniopharyngioma^{1–4} in which more patients with craniopharyngioma have been studied and followed, in some instances, for longer periods of time. In all series, however, including the present one, recurrences of craniopharyngioma are a fact of life. The rate of recurrence may be as high as 40% in some series. The treatment of the recurrent craniopharyngioma is a vexing problem, and one wonders whether patients who were first treated using the EEA would again be candidates for a repeated procedure using this approach.

The EEA described here was performed in adults. As craniopharyngiomas commonly occur in children, it would be interesting to use this approach in the child with a craniopharyngioma. In this regard, the limitations would likely be similar to those observed with the transsphenoidal approach in this age group: small nares, nonpneumatized sella, and smaller midline corridor between the carotid arteries.

Finally, as the authors expand their series and gather more patients for analysis, I exhort them to analyze the effects of EEA on the neuropsychology of their patients. It is here that I suspect that EEA may be a beneficial approach over craniotomy and subfrontal or pterional approaches to craniopharyngioma.

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Craniopharyngiomas

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“Craniopharyngiomas: transsphenoidal method of ap-

proach—for the virtuoso only?” is the title of the Ciric and Cozzens² presentation at the Congress of Neurological Surgeons meeting in Las Vegas, Nevada, in 1979. This question does not seem true but rather rhetorical, which is confirmed by the reasons reported by the authors. Coming almost 30 years later, the article by Gardner et al.—while observing the evolution of the technique, which is not limited as before to sellar lesions with suprasellar extension (preferably infradiaphragmatic or cystic), but is targeted to the suprasellar ones—raises further questions and at the same time reinforces the provocation of Ciric and Cozzens. As a matter of fact there are few brain lesions with such a multiform aspect and an unpredictable biological behavior as craniopharyngiomas, whose optimal treatment is controversial. If it is true that the radical surgical approach is the only therapeutic option to ensure a long-term control of the disease, it is also true that the price to pay for the radicality at all costs is sometimes very high in terms of functional outcomes, which may help explain why many different surgical approaches have been used for the purpose and the alternatives to the classic surgical indications, especially in cases of children.

In most cases, craniopharyngiomas are tumors located in the midline skull base. There are no other surgical approaches other than the extended transsphenoidal approach that offer the advantage to visualize the tumor just after the dural opening without brain retraction. No other approach provides a good and close visualization of the relevant anatomy, a direct trajectory, and a wide window. The transsphenoidal approach is even more attractive when the surgeon is dealing with a recurrence, which is quite common in these lesions, and the tumor can be controlled from a different perspective, thus avoiding new brain manipulation. Over the last decade tremendous efforts have been made to overcome some of the major problems that have provoked criticisms to such a technique, namely better-quality endoscopic images and new surgical instruments and tools to render the overall procedure safer and more effective.

Our experience³ is in agreement with the report of Gardner et al. They point out the crucial role of the endoscope in the transsphenoidal management of suprasellar skull base lesions in that there are no limitations created by the transsphenoidal speculum. Even more central is the importance they attribute to the perfect knowledge of the once-unfamiliar anatomy of the approach and the relevance of the team strategy to add competences to open and go along well new surgical tasks.

Gardner and associates describe 16 adult patients harboring craniopharyngiomas located above the sella, superior and posterior to the chiasm and even in the third ventricle. Six of these patients had previously undergone surgery or radiosurgery, which is in line with similar reports.^{3,5} Some aspects need to be highlighted. Near-total resection was attained in 12 (75%) of the 16 patients, which is a good result. The quality of life after surgery was good in all but 1 patient, who suffered a posterior cerebellar artery infarct. There was no worsening in the patients' ophthalmological conditions after surgery, and in fact almost all improved. All patients experienced excellent results in anterior pituitary function, which is not surprising given that the approach follows a supraglandular route. One patient suffered permanent DI and 4 suffered temporary DI, which seems like a good outcome, but it should be considered that the

stalk was preserved also in infundibular craniopharyngiomas, which can expose to recurrence. Four patients with Type II tumors experienced recurrence or regrowth without stalk sacrifice. No patient died as a result of surgery, and there were no cases of bacterial meningitis. The vascular injury rate was 5%, which seems a good outcome. The major complication was cerebrospinal fluid (CSF) leakage. Over the course of their study, the CSF leakage rate decreased from 70% to 20% in the more recently treated cases.

Currently, a major problem that might limit the procedure is the high rate of postoperative CSF leakage, and no radically effective solution has been found yet. In the effort to lower such a rate, we have followed some of the indications proposed by the Pittsburgh group, like the use of the Foley balloon to hold the reconstruction material(s) in place and, more recently, the nasoseptal mucosal flap.⁶ At the moment we have adopted the use of the nasoseptal flap in 12 patients who underwent an extended transsphenoidal approach for suprasellar lesions. In this cohort we experienced 5 cases of CSF leakage, 3 of which were intraventricular craniopharyngiomas. If we analyze our present series of 17 patients with craniopharyngiomas who underwent surgery via an extended transsphenoidal approach, we have experienced 5 cases of CSF leakage, 4 of which were intraventricular craniopharyngiomas. Three of these were reconstructed with the nasoseptal flap. These patients with intraventricular craniopharyngiomas are a very challenging subgroup. They present with a direct communication of the third ventricle with the nasal cavities, and they must undergo a wide arachnoid dissection. However, the postoperative CSF leakage rate reaches unacceptable percentages, and the expectancies of the nasoseptal flap seem to have failed their promises in these circumstances. In our opinion¹ it means that the reconstruction strategy is not yet fit to the purpose and that the solutions proposed (that is, multilayered planes, vascularized flap, and so on) are not completely adequate to the goal; none has been shown to reduce the rate of postoperative CSF leakage to an acceptable level (< 1%), as it currently is for the “standard” transsphenoidal pituitary surgery.

Nevertheless, as reported in some of our recent contributions^{3,4} the extended transsphenoidal approaches offer undoubtable advantages in better visualization of the subchiasmatic and/or intraventricular area, where several suprasellar craniopharyngiomas arise and/or extend, when compared with the transcranial operations. Another advantage of the low-route approach is that the procedure can be performed regardless of the position of the chiasm and the sometimes low position of the anterior communicating artery complex, which may lead to a very difficult tumor resection in all types of basal transcranial approaches. When performing the dissection under direct visual control, the extended transsphenoidal route permits surgeons to reach from below the various types of craniopharyngiomas. Using the same surgical corridor, but depending on the site of the lesion, the surgeon can work either below or above the optic chiasm with minimal optic apparatus manipulation and through both sides of the stalk, thus managing both the suprasellar prechiasmatic and the intraventricular craniopharyngiomas. The trajectory afforded by the transsphenoidal approach permits the neurosurgeon to work along the same axis of the path of this type of craniopharyngioma.

In such a way, also the purely suprasellar intraventricular masses, which are associated with a small or normal-sized sella and are traditionally considered unsuitable for the transsphenoidal route, can be successfully removed with this technique.

Nevertheless, not every patient with a craniopharyngioma is a good candidate for such an extended approach. The degree of pneumatization of the sphenoid sinus plays a major role. A presellar- or conchal-type sinus represents a relative contraindication to an extended approach because the main landmarks within the sphenoid sinus are not well recognizable, thus increasing the risk of injury to the intracavernous internal carotid arteries and the optic nerves. A high dorsum can render the procedure more difficult, especially in the case of retrosellar extension of the lesion. The anterior intercavernous sinus can influence the bone resection given that it can bleed profusely. The consistency, blood supply, and adherence to the surrounding neurovascular structures by the tumor can represent an obstacle for the approach. In addition, the narrow space for the instruments might create problems in cases of hemorrhage, given that control of the bleeding is mandatory to work in a clean surgical field. Other limitations should not be underestimated, such as the following: 1) the need for an incremental acquisition of skills before becoming confident with the peculiar anatomy and the manipulation of all structures, as seen from below; 2) the necessity for dedicated instruments, all of which as yet are not available; and 3) lack of initial skill, which makes the operative times longer. The time required for an extended approach in our experience is still superior to that needed using a transcranial approach.

Returning to the title question of Ciric and Cozzens, extended transsphenoidal surgery should be left in expert surgeons' hands. Perfect knowledge of anatomy, fine technical skill, talent, and a strategic team approach are required; Gardner et al. have shown these qualities. However, these are not enough to put the words "the end" to the whole story. Surgeons must decide the appropriate balance between the reality of the situation and the rules. A sense of measure is needed to read and to join the flaming beauty of the reality with the cold severity of the rules. The rules concerning many aspects of the procedure need some more work and solutions need to be defined, as well as the development and improvement of the specific instruments for the procedure and the ideal technique of reconstruction of the approach. Then it will be necessary, as Gardner and colleagues affirm, to analyze larger series and longer follow-up, and the appropriate indications for this rather than other surgical solutions can be defined. In the meantime there will be those who will be playing the role to push the frontiers and others who will move in subsequent advancements, trying to be at the same time in the game and in the posse, which is not always easy or even possible. Nonetheless, surgeons are eager to know the cure rate of tumors in patients who undergo such an approach, the effectiveness of this procedure, and the indications to use it instead of other approaches, which are not yet possible to define.

We need to keep working hard, to participate in the ongoing international scientific debate without preconceived ideas, and to study and understand our efforts to validate them. Craniopharyngiomas are very challenging lesions, and sometimes it is the lesion and not the surgeon that decides the destiny of the patient. So the task is to try to un-

derstand in advance which is and will be the best proposal for the individual with a craniopharyngioma.

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Response

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At the onset we are very grateful for the comments provided by both Drs. Rutka and Cappabianca. We would like to address each separately.

With respect to Dr. Rutka's comments, we found them to be thoughtful and insightful as they addressed the key issues related to the management of craniopharyngiomas through the EEA. Important considerations are raised relative to the practical value of the classification proposed in this study. We do agree that it can be difficult to preoperatively distinguish the craniopharyngioma subtype based on MR imaging findings. Having said that, using high resolution, thin-section, axial MR images we found this to be a problem in a minority of cases. Starting at the level of the third ventricle from a rostral to caudal direction with the aid of axial images, one can usually identify the stalk's origin and follow it down to the sella, noting the greater part of the tumor's position relative to the stalk. In invaginating lesions that engulf the region of the suprasellar cistern this may not be possible, and the only way to classify the lesion with certainty may be at the time of surgery. Therefore, in practice, we propose this classification not necessarily exclusively for preoperative planning, but also for intraoperative management, as we have found it extremely useful at the time of surgery. The information gleaned from the preoperative MR images can then be augmented with the unique visualization provided endoscopically, particularly with the advent of new high-definition optics, to better de-

lineate the subtype of craniopharyngioma. Given the fact that the surgical technique is modular, this allows for strategic modifications at the time of surgery. For example, if the lesion is believed to be retroinfundibular preoperatively, and this is verified intraoperatively, then the additional module of a pituitary transposition with posterior clinoidectomies and dorsectomy can be added.⁶ We believe the classification's value is to provide a conceptual framework that provides a surgical approach algorithm. Specifically, in the case of retroinfundibular lesions posterior to the Liliequist membrane, rather than trying to gain access through the suprasellar cistern and risking injury to vasculature that may be adherent to the tumor's posterior wall, a pituitary transposition will allow direct access to the posterior circulation providing for controlled dissection through a relatively much larger working window.⁶ We would like to clarify that we are not suggesting that the classification be applied exclusively based on preoperative imaging and in fact suggest that it is only at the time of surgery that preoperative perceptions can be confirmed. We thank Dr. Rutka for pointing this out.

Next, Dr. Rutka raises the critical issue of long-term data collection and neuropsychological outcome. This part cuts to the heart of craniopharyngioma management. Our study is flawed by the lack of long-term data as well as neuropsychological outcomes. We provide the study only as a proof of concept and look forward to capturing these data to determine if, in fact, there is true value to our approach. Toward this end, a separate prospective study has been undertaken looking at pre- and postoperative neurocognitive function. Preliminary results at this stage seem encouraging and appear to confirm Dr. Rutka's impression that EEA will have significant benefit.

We are most grateful for Dr. Rutka's thoughtful comments and concur with him on every aspect of his review. Two additional questions that were raised, that is, the applicability in pediatric patients and recurrent disease, are discussed later.

With respect to the review and comments made by Professor Cappabianca et al., we would like to address them systematically. To allow for adequate follow-up, the last patient included in this series underwent surgery in February 2006. Since that time, an additional 18 patients have undergone EEA for resection of craniopharyngiomas at the University of Pittsburgh Medical Center. In an effort to address some of the concerns raised by the review from Dr. Cappabianca et al., as well as the comments based on their own personal series of 17 patients, we provide an update on our entire cohort of 34 patients (16 patients reported originally and 18 subsequently). The group of 18 additional patients (10 males and 8 females) with craniopharyngioma had a mean age of 41.1 years. Five of the 18 patients were children, the youngest being 9 years.

We agree with these reviewers' comments on the advantages of accessing a midline lesion through a midline corridor. We respectfully disagree, however, with the proposed limitations offered. Cappabianca et al. mention the degree of pneumatization, presellar/conchal-type sinus, and a high dorsum sella (for retroinfundibular lesions) as relative contraindications to the endonasal route. Although we believe that these represent challenges, it is precisely in this setting that the classification is useful. For example, in the case of high dorsums, the modular approaches with pi-

pituitary transposition allow for direct retrodorsal lesion access with immediate isolation and control of the posterior circulation.⁶ This obviates the limitation of working in a small dark hole as these authors point out when one approaches retrodorsal lesions through a purely suprasellar corridor. With regard to degree of pneumatization, we have not found this prohibitive in any case. Understanding of key anatomical landmarks, such as the vidian nerve⁸ and the medial clinoid,⁷ overcome these issues. These latter issues are especially germane in pediatric patients. We have performed EEAs for diverse pathological entities in patients as young as 3 years of age.^{7,9} In the updated craniopharyngioma series discussed earlier, we have been able to undertake EEA for craniopharyngiomas in a child 9 years of age.

The next issue raised by Cappabianca et al. focuses on the management of CSF reconstruction. Although we agree completely with the authors' perspective on the need to reduce this complication to an acceptable level, we also believe that there are several important points that need to be considered. Early in our series we experienced an exceptionally high rate of CSF leakage (70%); however, the overall rates of other outcomes (vision, endocrine, and so on) were very encouraging (as reported in this paper). The incidence of vascular complication was 6% (1 of 16) in the original series and 3% (1 of 34) in the updated series. Based on these findings and the fact that we did not see a significant incidence of meningitis, we were encouraged to continue with the endonasal route while seeking improved reconstruction solutions.⁴ We believe the development of the nasoseptal flap has, in fact, been a significant evolution in this effort.^{3,5} Cappabianca et al. report a relatively high failure rate with the use of this flap in their early experience, particularly in this population of craniopharyngiomas, and they attribute this failure to the pathology and degree of anatomical dissection (that is, wide arachnoidal cisternal opening and ventricular communications). We have previously identified these as critical factors impacting reconstruction.⁴ At the time of publication of our original series of 16 patients, we were just gaining experience with the vascularized nasoseptal flap.³ In the subsequent 18 patients in the updated series who were consistently reconstructed using the nasoseptal flap, postoperative CSF leakage occurred in only 1 patient. Therefore, the CSF leakage rate has been reduced to 5.56%, which is at least comparable to multiple series of open approaches for anterior fossa pathologies.^{1,2} We again respectfully disagree with the statement from Cappabianca et al. that the CSF leak must be reduced to < 1% when resecting craniopharyngiomas through this route. The comparisons between pituitary surgery and craniopharyngioma surgery are not valid by virtue of the fact that (as Cappabianca et al. have stated) wide arachnoidal cisternal opening and ventricular communications are prerequisites in the latter compared with the former. A leakage rate of 5% is consistent with that noted after many skull base approaches used for transcranial craniopharyngioma surgery.

In terms of these reviewers' statement that "the expectations of the nasoseptal flap seem to have failed their promises" we would like to clarify that we have made no promises but simply offered an alternative for vascular reconstruction. There are many groups currently using the flap successfully. There are critical nuances that are inher-

ent in raising the flap and we leave this portion of the procedure to the otolaryngologist who is more familiar with the regional anatomy, the contents of the pterygomaxillary fissure, and the distal branches of the internal maxillary artery that form the pedicle. In our institution, these flaps are raised by an experienced otolaryngologist in each case. This is precisely why we pursue a team approach (otolaryngologist and neurosurgeon). In addition, there is clearly a learning curve associated in raising these flaps as our results have improved over time.⁵

We completely agree with both Professors Rutka and Cappabianca et al. that the goals of surgery need to be tempered to ensure optimum outcomes. There are additional tools available to the surgeon in the management of this disease, including radiation therapy and reoperation. The ideal surgical approach should be one that minimizes morbid outcomes, optimizes function, and does not preclude reoperation when needed. We have found EEA well suited for reoperation when required whether the patient has had previous surgery and/or radiation. As demonstrated in this series, none of the recurrences that required repeated EEA suffered a new complication.

Finally, we agree with Cappabianca et al. that this is “not the end of the story.” We have never suggested that EEA is a curative procedure for craniopharyngiomas or that it represents the only viable option. In fact, in our classification scheme we present 4 categories of craniopharyngiomas. The first 3 can be addressed by EEA, whereas Type IV in our opinion is best treated via a transcranial route. We offer this midline corridor to simply augment the surgeon’s armamentarium. (DOI: 10.3171/JNS/2008/109/7/0001)

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