The Frontotemporal Epidural Approach Combined with Temporal Polecetomy for Surgical Resection of Clinoidal Meningiomas

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Abstract

Objectives: The objective of this study is to examine the effects of combining pealing of the outer layer of the lateral wall of the cavernous sinus with temporal pole resection on the safety, radicality and operative time when used for the surgical resection of clinoidal meningiomas.

Patients and Methods: 12 patients with clinoidal meningiomas were operated at Cairo University Hospital in the period between January 2009 and December 2011 using this technique. Patients were followed-up for a period ranging between six months and one and a half years. The technique comprises of epidural devascularization followed by a temporal pole resection in all patients. All patients were prepared for by pass in case inadvertent rupture of the internal carotid artery would take place. This was followed by resection of the part of the tumor in the middle fossa all the way up to the free border of the tentorium. The Sylvian fissure was then split and neurovascular dissection was done provided there is a good arachnoid plane.

Results: The epidural approach resulted in a complete devascularization of the tumor in all except one case 8.3%. A good arachnoid plane was found in 75% of cases which allowed for a radical resection in these cases. No mortalities and no intraoperative carotid artery injury took place in the present series. 41% of cases developed a postoperative communicating hydrocephalus. However, only 16.6% required C.S.F diversion. 8.3% of cases developed diabetes incipidus, third cranial nerve paralysis or internal jugular vein thrombosis.

Conclusion: The absence of intraoperative carotid artery or major neurovascular structure injury together with an incidence of radical resection comparable to other series using other approaches indicates that the present approach described, renders clinoidal meningioma resection safer and less time consuming.

Key Words: Clinoidal meningioma — Skull base approach — Temporal polectomy.

Introduction

CLINOIDAL meningiomas are among the most challenging tumors in skull base surgery [1-3]. This has been mainly attributed to the high incidence of complications reported during or following their resection. In practice, the most important complication encountered is intraoperative carotid artery injury. A carotid artery or one of its major branches, encased by tumor, in the absence of a good arachnoid plane of dissection, is the usual cause of major intraoperative vascular injury.

Such procedures being lengthy and tedious, and such tumors being most commonly vascular, result in a difficult neurovascular dissection. Neurovascular dissection is particularly difficult, as it starts at a relatively late stage of surgery. This also makes it difficult to make a sound judgment, as to whether the tumor should be totally or sub totally resected. We are proposing a skull base technique combined with a temporal polectomy, aiming at early epidural tumor devascularization, and size reduction which shortens the operative time, by allowing rapid and early resection of relatively safe and large parts of the tumor [4-6]. This preserves the neurosurgeons energy and concentration for neurovascular dissection. The technique also allows a sound judgment to be made at an early phase of surgery as regards which tumors should be totally and which should be only sub totally resected.

Material and Methods

12 patients with clinoidal meningiomas were operated upon at Cairo university hospitals in the period between January 2009 and December 2011. All patients were examined neurologically before surgery with a special emphasis on visual deficits and oculomotor nerve involvement. All patients
were subjected to MRI, MRA and CT before surgery. Angiography was not used in any of our patients and no patients underwent a balloon occlusion test. All patients were assessed clinically after surgery. A follow-up CT was done in all patients in the immediate post-operative period and a follow-up MRI with contrast was done 6-8 weeks following discharge. Patients were followed-up for a period of 6 month to 1.5 years following surgery on an outpatient basis. Data were prospectively collected and retrospectively analyzed at the end of the study.

Surgical technique:

Cervical carotid artery exposure:

After induction of general anesthesia and before head positioning all patients are placed in the supine position with the head rotated to the contralateral side and the neck hyperextended. A longitudinal incision is then made in the neck followed by exposure of the common, internal and external carotid arteries on the side of surgery with placement of vascular slings across each in preparation for proximal control or subsequent bypass.

Radial artery exposure:

In the meantime the left radial artery is exposed and prepared for a possible bypass procedure, but not harvested unless needed.

Craniotomy and extradural skull base approach:

The head is then positioned in a three point Mayfield head clamp and a standard frontotemporal craniotomy is done using a standard technique.

Following craniotomy the lesser wing of the sphenoid bone is resected followed by an orbitotomy, opening of the superior orbital fissure and, division of the tentorial duplicature to peel the outer layer of the lateral wall of the cavernous sinus.

The middle meningeal artery is then divided, and the greater superficial petrosal nerve is exposed. Exposure of both Glasscock's and Kawases triangles is then completed in cases that require that the posterior cranial fossa would be entered. Following pealing, the dura on the basal temporal lobe is coagulated with bipolar coagulation. This causes devascularization of the tumor extradurally and shrinks the temporal lobe dura allowing elevation of the temporal lobe off the skull base.

An extradural anterior clinoidectomy is then done with opening of the optic canal. However, this is only performed in cases where the imaging clearly shows the tumor to arise from the upper surface of the anterior clionoid process. In doubtful cases this step is reserved to the end of surgery after complete tumor removal and here the anterior clinoid process is removed intradurally.

Dural opening, lobectomy and middle fossa tumor resection:

After completion of extradural devascularization the dura is opened and a temporal polectomy is performed as a routine procedure in all patients to allow for brain relaxation and exposure of the part of the tumor in the middle cranial fossa which is resected all the way up to the tentorial free border.

The brain, now being relaxed, and the middle fossa part of the tumor resected (which in most cases is a large part of the tumor). Neurovascular dissection is then started.

Neurovascular dissection:

The Sylvain fissure is widely split, and the middle cerebral artery is exposed. At this stage the arachnoid is tested to determine whether a good arachnoid plane exists between the meningioma and the middle cerebral artery. If a plane could be found, the tumor is then dissected sharply in the arachnoid plane all the way down to the carotid bifurcation. At this stage the tumor is then followed on its medial aspect and the tumor dissected from the optic nerve.

The tumor is then debulked and elevated off the nerve and the upper surface of the carotid artery exposing its bifurcation as well as the proximal parts of the anterior and middle cerebral arteries. Attention is now shifted to the part of the tumor which is located lateral and inferior to the internal carotid artery and here this piece of tumor is dissected carefully to search for the posterior communicating artery as well as the third nerve. A good arachnoid plane usually exists between the tumor here and the third nerve in most cases. This part of the tumor is also followed into the posterior cranial fossa taking care not to peel the tumor off the brain stem unless sure that a good arachnoid pia interface is seen. This can be usually demonstrated before surgery by the absence or presence of a hyper intense signal in the brain stem on T2WI. In cases that show difficulty in establishing an arachnoid plane the tumor is usually debulked and a sheet of tumor is left on the vessels and/or the brain stem accordingly. Table one shows the details of all patients included in the study.
Table (1)

<table>
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<tr>
<th>Patient number</th>
<th>Age/ Sex</th>
<th>Preoperative visual deficit</th>
<th>Postoperative visual outcome</th>
<th>Tumor size</th>
<th>Extent of resection</th>
<th>Complications</th>
<th>Pathology</th>
</tr>
</thead>
<tbody>
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<td>RT-</td>
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<td>Hemangiopericitoma</td>
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Case presentations:

Case 1:
This is a 63 year old male patient, who presented with headache associated with vomiting and fits. The tumor was arising from the superior surface of the anterior clinoid process. The patient was operated using the frontotemporal epidural approach combined with a left temporal polectomy. The tumor was completely resected. A CSF collection persisted after surgery for 3 months. Insight of medical treatment. This was treated using a theco-peritoneal shunt and resolved completely. Figs. (1,2) demonstrate pre and postoperative images depicting total removal of the tumor.

Case 2:
This is a 36 year old female patient. The patient presented with headache associated with diminution of vision on the right side. Preoperative radiology revealed a clinoidal meningioma. The tumor seemed to be arising from the superior and lateral surface of the anterior clinoid process. A preoperative CT Angiography revealed an almost complete encasement of the carotid bifurcation and the ICA. The tumor was extremely vascular and there were multiple areas of arteriovenous shunting on the tumor surface. The patient was operated using the
same approach, and the tumor was completely resected. However, the extreme vascularity necessitated preoperative embolization. This patient developed cerebral salt wasting, bilateral frontal cerebritis, internal jugular vein thrombosis and a CSF fistula due to communicating hydrocephalus. The hydrocephalus manifested with a subgaleal CSF collection and an occasional leak. All complications were treated medically, and a theco-peritoneal shunt was inserted for persistent communicating hydrocephalus. Figs. (3,4) demonstrate preoperative MRI and CT Angiography depicting tumor size, relations and extreme vascularity and vascular encasement. Postoperative image Fig. (5) shows complete tumor removal.

Results

Presenting symptoms and signs:
6 patients (50%) presented with deterioration of vision, one patient (8.3%) with diplopia, 4 (33.3%) with seizures and 10 (83.3%) patients with headache.

Surgical findings:
9 patients (75%) showed a good arachnoid plane between the tumor and the internal carotid artery. In all nine the plane could be traced from the middle cerebral artery distally to the internal carotid artery proximally. In this group of patients a radical resection was possible. In three patients (25%) no arachnoid plane could be traced one (8.3%) of which was previously irradiated rendering it impossible to achieve a radical resection and all three (25%) were resected sub totally.

In all cases (25%) where the arachnoid could not be traced it was found that the plane was absent right from the start at the level of the middle cerebral artery.

The epidural approach succeeded at devascularization of the tumor completely in all except one case (8.3%). This resulted in a faster and much easier procedure. Only in one case (8.3%) of hemangiopericitoma this was not the finding. This patient had to be operated in two settings and was embolized before the second setting. Inspight of embolization the patient received 12 units of blood during surgery.
Neurological complications and outcome:

There were no mortalities in the present series and no patients suffered an intraoperative carotid artery injury. One patient (8.3%) developed a postoperative ptosis which resolved spontaneously in 3 months. 5 patients (41%) developed a postoperative communicating hydrocephalus. This manifested either by a CSF fistula or by a subgaleal CSF collection. Only 2 patients (16.6%) required CSF diversion using a lumboperitoneal shunt. In the remaining 3 (25%) patients the leak or the collection subsided spontaneously with no need for surgical treatment. 2 patients (16.6%) developed a skull osteomyelitis which was managed conservatively with no need for surgery. One patient (8.3%) developed a cerebral salt wasting as well as diabetes incipidus which were treated and subsided within a period of 1.5 months. This same patient developed a left internal jugular vein thrombosis and was put on anticoagulation. This patient was one of the two patients that required a lumboperitoneal shunt. This patient also developed a bilateral frontal lobe cerebritis which was treated medically and subsided but left the patient with a mild memory deficit.

Extent of resection:

9 cases (75%) were resected totally and 3 (25%) were resected subtotally. The three cases that were resected subtotally all showed absence of an intraoperative arachnoid plane to cleave the tumor from the internal carotid artery. One of the cases subtotally resected was previously irradiated.

Visual outcome:

4 (33.3%) of the 6 (50%) presenting with visual deficits showed improvement while 2 (16.6%) stayed the same.

Tumor recurrence:

There were no recurrences reported over a 1.5 year follow-up period.

Pathological findings:

Only one case (8.3%) in the present series had a hemangiopericitoma and the remaining 11 (91.6%) had meningiothelial meningiomas one of which was of the psammomatous type.

Discussion

A number of authors have claimed clinoidal meningiomas to be one of the most difficult tumors in skull base surgery. This reputation has been acquired, by the high incidence of complications reported in most series. Most complications are caused, by direct neurovascular injury to the optic nerve, carotid artery or one of its branches or the brain stem [2,4]. This is usually the result of involvement of one or more of these structures by tumor rendering dissection very difficult [7].

Our rationale of resection is based on the fact that such procedures are usually lengthy and tedious. The length of surgery is mostly the result of consuming a long time to devascularize the tumor intradurally, so that by the time the surgeon reaches the most critical and important step which is the dissection of the internal carotid artery much of the neurosurgeon’s energy and concentration have already been lost. This usually results in inadvertent intraoperative carotid artery, anterior cerebral or middle cerebral artery injury [8,9]. The absence of intraoperative vascular injury in our study; in addition to a significant reduction in operating room time, reflect the ability of the approach to bring neurovascular dissection to an early phase of surgery. This is in contrast to what has been described in earlier series. Sekhar et al., have reported 3 cases of carotid artery injury in their series that required bypass as salvage procedures 110,111.

Most authors agree that the blood supply in such cases comes mainly from the middle meningeal artery as well as branches of the meningohypophyseal trunk along with some branches from the anterior and posterior ethmoidal arteries [12,13]. After the neurosurgeon peals the outer layer of the lateral wall of the cavernous sinus after dividing the dural duplicature, early, and almost complete interruption of the blood supply takes place. This step also allows for the division of the middle meningeal artery at the foramen spino-sum. This causes an almost complete interruption of the blood supply of the tumor so by the time the surgeon opens the dura for tumor resection the tumor is already devascularized removing the need for intradural devascularization almost completely. This has been reflected in a much shorter operative time than that reported in most series 1141.

The pattern of neurovascular displacement and involvement in clinoidal meningioma is dictated by its site of origin from the anterior clinoid process. Tumors that arise from the superior surface of the anterior clinoid process usually have no temporal fossa extension and stay completely above the internal carotid artery. They displace the carotid artery and its bifurcation inferomedially and posteriorly [1,2,15]. Tumors that arise from the lateral surface of the anterior clinoid process show varying
degrees of temporal fossa extension and it is this group that is usually responsible for encasing the internal carotid artery. This group usually shows good arachnoid and is possible to resect completely even if the artery appears to be completely encased [1,2]. There is yet another group that arises from the inferior surface of the anterior clinoid process. This group usually has no arachnoid plane at all. A number of authors agree that this group cannot be completely resected because no arachnoid plane could be established.

Also, an intracranial to extra cranial by-pass procedure has been proven by most authors to be of no help as the bypass will not be able to replace the valuable perforators and branches arising from the ICA unlike in cases of aneurysms of the giant type where the intraluminal thrombus makes the perforators nonfunctioning and accordingly the main vessel can be replaced by a bypass. Early identification of this group during the course of surgery is important to prevent inadvertent intra-operative rupture of the internal carotid artery [1,2,16,17].

Following opening of the Dura a generous temporal lobectomy is performed in all cases and its extent is dictated by the hemisphere being operated weather it is dominant or not. This step has proven to be helpful in many ways. This helps to extensively reduce intracranial pressure because it alleviates the tension created at the base of the brain. It exposes and sets the stage for very easy and rapid removal of the tumor at the middle fossa which is a safe and usually large part of the tumor up to the tentorial edge. By the time the neurosurgeon starts to split the Sylvain fissure the brain is lax and the tumor is avascular and more than half of the tumor has been removed.

75% of our cases were resected totally and 25% sub totally. This incidence of resection is comparable to that reported in other series [18,19]. Although the present technique has shown an extent of resection comparable to that described elsewhere yet the operative time has been considerably reduced. This has led to absence of carotid artery injury in this series and accordingly no mortalities were reported in the present series which contradicts to what has been previously reported by other authors, who reported a 12% mortality resulting from vascular injury mainly in their series [11,12,20].

33.3% of patients with preoperative visual deficits showed visual improvement while 16.6% stayed the same. This can be explained by the resection of the tumor involving the optic nerves and can also be explained by the extradural resection of the anterior clinoid as well as the opening of the optic canal which is often involved by tumor in such cases as well as hyperostitic bone [11,12,21,22].

Regarding post-operative complications 8.3% of patients developed a postoperative ptosis due to third nerve manipulation and this resolved spontaneously in 2 months. 41% of our patients developed a post-operative communicating hydrocephalus as manifested by a subgaleal CSF collection or a CSF leak. Only 16.6% required treatment. A lumboperitoneal shunt was inserted and did not need further treatment. 16.6% of patients developed an osteomyelitis of the skull and were managed conservatively with no need for further treatment. Other series have reported a similar incidence for such complications [23-25].

One of our patients needing shunt insertion also developed cerebral salt wasting and diabetes insipidus which resolved within one month of treatment. This same patient developed a left upper limb deep vein thrombosis along with thrombosis of the internal jugular vein which were managed with anticoagulation and recanalized in 45 days. This same patient developed a bilateral frontal lobe cerebritis which was treated but left the patient with a minor memory and behavioral deficit. The incidence of complications reported coincides with the work of a number of authors who reported a similar complication rate [23,25].

The use of cervical carotid artery and radial artery exposure in such cases routinely was not needed in all cases that were operated. It added one to two hours to the operative time unnecessarily. However, it is an important save guard in cases of vascular injury in case a salvage bypass would be needed [11-13].

The small number of cases in this series makes it difficult to draw solid statistical conclusions regarding this approach. However, we do intend to pursue the same approach on a longer term in a larger number of cases to determine whether sound conclusions can be drawn as regarding its recommendation as a standard approach for operating tumors in this location.

Conclusion:
The use of the frontotemporal epidural approach combined with temporal pole resection causes an early and rapid devascularization of the tumor. This paves the way for early removal of larger and
relatively safe parts of the tumor. The result is bringing neurovascular dissection to an early phase of surgery. This allows a sound judgment to be made as regards cases that should be resected totally and cases that should be only subtotally resected. This results in the absence of major vascular or neurological injury. Accordingly, this approach renders clinoidal meningioma surgery safer and less time consuming.

References