SKULL BASE SURGERY – FRACTURES AND PITUITARY GLAND TUMORS

Marko Zorić, MD

Abstract

Skull base surgery is a subspecialty involving many surgical fields such as neurosurgery, otorhinolaryngology, maxillofacial surgery, plastic surgery and other nonsurgical specialties. Because of the multidisciplinarity it is considered as one of the most complex parts of modern medicine. The bigger part is the pituitary surgery with two main approaches: microscopic transsphenoidal surgery (TSS) and endoscopic transsphenoidal sinus surgery (ETSS). Systematic reviews and meta-analyses show very good results for these procedures even though they can have many complications. Another part that shouldn’t be forgotten is the trauma of the skull base. A lot of effort is given to improve these procedures by using more technology especially different navigation systems or robotic hands.

KEYWORDS: endoscopic transsphenoidal sinus surgery, multidisciplinarity, pituitary tumours, skull base fractures, transsphenoidal surgery

INTRODUCTION

Skull base surgery is considered as one of the most complex parts of neurosurgery and surgery in general. Like the name denotes it is a surgical procedure in which the surgeon operates different kinds of pathologies in the bottom/base of the human skull. This area is highly demanding because of the anatomy of the skull base with many bones and foramina containing all kinds of nerves, arteries, veins and any harm could cause catastrophic damage and decrease the quality of the patients’ life. The skull base is divided in 3 parts; anterior, middle and posterior fossa. The anterior part lays between the posterior wall of the frontal sinus and the clinoid process of the sphenoid bone, the lateral part of the anterior fossa is formed by the frontal bone. The middle fossa is behind the anterior part, the clivus is the central part, the petrosal part forms the lateral border, and from the extracranial aspect the petrooccipital fissure divides the fossa into the lateral and medial part. The posterior fossa is formed primarily by the occipital bone and parts of the temporal and sphenoid bone which form the lateral walls. All these three divisions contain many foramina with vital neurovascular structures such as the carotic artery, jugular vein, cranial nerves and many others. Because of that it is very demanding and to preserve these structures it is highly multidisciplinary, neurosurgeons, otorhinolaryngologists, maxillofacial surgeons, plastic surgeons, endocrinologists, pathologists, oncologists, radiologists and anaesthesiologists work all together in the benefit of the patients. Why is that so important?

MULTIDISCIPLINARITY

In this type of very specialized surgery, which demands not only open but also endoscopic surgery it is crucial that different specialists combine their skills. It is hard to believe that one specialist is well trained in all principles of skull base surgery. The general training during residency in otorhinolaryngology is reserved in the field of oncology on open skull base approaches, and endoscopic procedures are more reserved for smaller and benign tumours, on the other hand neurosurgery residents have little education and experience with endoscopy because of their narrow usage in neurosurgery for ventricular tumours and 3rd ventriculostomy which are considered as one of the most difficult surgeries. A good skull base surgeon should be well familiar with the principles of oncological treatment, he should perfectly know the anatomical approaches and especially the vascularisation because the biggest complications are those of vascular pathology caused by bleeding. Training should be very rigorous. One way to learn and practice before the operation room is on special courses on human cadavers but these are very expensive. An alternative which could be proposed is the training on lamb heads. Two authors from Croatia investigated the lamb head as a model for the endonasal endoscopic surgery (ESS) procedure but also the skull base surgery, this method is cheap and many practical skills can be practiced such as orbit decompression and cerebrospinal fluid leak repair. The limitation is that this type of training is suitable only for beginners in the field of endoscopic surgery and also quadrupeds do not have a sphenoid sinus and procedures including this sinus cannot be practiced.
Complications occurring are not to forget, most of them are infectious. A study from a group of authors showed that anterior skull base surgeries have up to 40% complications. Among 53 surgical procedures for benign (cerebrospinal leak, juvenile angiofibroma, mucocele, meningioma) and malignant tumours (adenocarcinoma, chondrosarcoma, malignant meningioma, neuroendocrine carcinoma). Combined ortho neuroradiologists and neurosurgeons used mostly a bifrontal and transsphenoidal approach and 21 patients had complications and 1 patient died from myocardial infarction. The most common complications were cerebrospinal fluid leak and meningitis which required reoperation in 1 case. An interesting fact described that the postoperative complications were similar without any statistical significance between patients who underwent prior chemotherapy, radiotherapy and surgery compared with those without any procedure before.

Training will perhaps look differently in the future. Some novel studies try to ease this process by making 3D phantom models, so that learning may be faster than nowadays. Using multiple materials offers a realistic anatomical reconstruction received prior to the procedure from patients CT (computed tomography) or MRI (magnetic resonance imaging) scans. Even more this offers also for surgeons to get familiar with all possible anatomical variations and, of course, the surgeon gets the opportunity to have a “practice” operation on the 3D phantom model before the real operation in the operating room.

Future development may encourage the use of robots in skull base surgery. There is no doubt that new technologies are constantly being implemented in medicine so it isn’t a big surprise. Some experimental studies on cadaveric human skulls show promising facts. Using a robotic hand via the Da Vinci Surgical System combined with CT image guidance may lead to better treatment of oncological patients, especially using transoral robotic surgery (TORS) for some tumors with difficult access trajectories. The limitations are the difficulty to operate precisely with these instruments, and the fact that there are no detectors on the instrument of the robotic hand, so it possible to damage a blood vessel, healthy tissue or nerve without noticing, thereby causing tremendous damage.

**PITUITARY TUMOUR PATHOLOGY AND CLINICAL FEATURES**

The biggest part of skull base surgery definitely goes to the pituitary tumor surgery. They are quite common and sometimes require surgery. They can be divided depending on their size on macroadenoma (diameter >10 mm) or microadenoma (diameter <10 mm), secondly based on their hormonal activity (functional or non-functional) and depending on their histology (prolactinoma, somatotropinoma, corticotropinoma etc). They occur in younger and middle aged people, and some molecular mechanisms and mutations are well known (\text{\textit{A)}}, PRKARIA, MENI). Clinical features are neuroophthalmological, causing vision defects...
and headaches or due to their hormone secretion leading to endocrine disorders.16

After that, the next step to the diagnosis is the imaging of the tumor with a CT or/and MRI scan. The benefit of the CT scan is that it is helpful for the possible surgery by obtaining very important information about the bone anatomy of the patient, especially about the sphenoid sinus and carotid canal, and, of course, it can show possible anomalies. The advantage of the MRI scan is the better visualization of the tumor, tumor size and the soft tissues in the surrounding regions.17 After all that there are several potential treatment options: surgery, pharmacological treatment or radiotherapy. Pituitary tumours are mostly treated surgically.18

Figure 2. Endonasal surgery. Used with permission courtesy of the Medical Tourism Association.

TRANSPHENOIDAL SINUS SURGERY (TSS) AND ENDOSCOPIC TRANSPHENOIDAL SINUS SURGERY (ETSS)

The first operations began in the first decade of the 20th century in Italy and Austria. They used a transphenoidal approach, transphenoidal sinus surgery (TSS) meaning an approach through the nose and drilling a hole in the sphenoid sinus to get to the sellar region where the pituitary gland lays. It was a well established pathway for these tumours, but another method including an endoscope is proposing the endoscopic transphenoidal sinus surgery (ETSS).19 It is considered as a more effective and better option.19 Via the endoscope the surgeon has multiple advantages: it causes less retraction of the neurovascular structures and by protecting them major complications are avoided, because of the flexibility of the endoscope it gives the surgeon a better vision on the operation field but he must have good anatomical knowledge because looking on familiar structures from other angles can be confusing.14 Something that should be taken into account is that the surgical team must be well trained and know how to deal with vascular complications. This is important for the tumours that are near the carotid artery and cavernous sinus involving (cst).18 The operation is performed in a full intravenous anaesthesia and patient is lying supine, while the head is above the level of the heart. As a prophylaxis ceftriaxone 1g is given 1 hour prior to surgery.20 When entering the nose and then approaching the sphenoid sinus the surgeon drills the sinus and if there is a septum dividing the sinus the septum is drilled because it enables more place for the surgeons and his instruments.21 Then slowly continuing to the pituitary gland and the tumour, first after drilling the bone superior the surgeon makes an incision of the dura and reveals the tumour. Then he starts the slow debulking and tumour reduction with aspiration and thermocoagulation, watching not to damage the cavernous sinus and optic nerve.22 Today neurosurgeons have sometimes the comfort also to use different electromagnetic and optic navigation systems with a precision up to 2 mm or more- This can be really good but it is not advised for the surgeon to rely only on the navigation system.8

After the tumour is partially or totally removed it is incredibly important to reconstruct the skull base defect which can cause fatal meningitis, brain abscess and eventually death.23 To avoid all that surgeons use different materials to cover that defect, mostly an avascular flap - the fascia lata for smaller defects or vascular flaps such as the Hadad- Bassagastaguy flap from the muchohondrium of the nasal septum for bigger defects.24 The complications are mostly due to infection or bleeding, the rate is about 5% or lower.25 Postoperatively, the urine output and the hormone status should be monitored because of diabetes insipidus, a common occurrence.26 Hormone replacement therapy is sometimes also needed.27 Standard control check ups are important to see if the tumor is totally or partially removed and to see the condition of the patient. The surveillance for the first 5-10 years is annual with neuroimaging data (MRI scan) and later it can be made every 2-5 years.28 In some patients the tumour recurs and they need surveillance every 6 months, and in some cases, a second line of therapy after surgery. Some factors are more correlated with these situations such as: residual tumour after surgery, silent corticotropine tumours and tumours expressing Ki67.29 They need afterwards pharmacological agents GnRH agonists, temozolomide, radiation therapy (stereotactic or conformal) or revision surgery.11 In children these tumours are not common bit some findings say that the growth can begin in that age and grow until adulthood when they become clinically significant.30
SKULL BASE FRAC TURES

Head trauma is a very common cause of disability in the Western World especially in the population from 20-45 years. It includes traffic accidents, falls, fights etc. Depending on the severity it can cause no harm or very serious complications such as coma, immobility, seizures and many other irreversible neurological impairments and in most serious cases death. That is one reason more why it is important to know how to treat and recognize these situations. There are well established procedures for head trauma but something what is causing arguments is the classification of skull base fractures. During history there were many classifications proposed but like the AO classification for bone fractures there is a AO-M three level classification for craniomaxillofacial fractures. The first level denotes the elementary region of the fracture, the second is for the topography to the surrounding structures and the third level outlines the type of the fracture morphologically. This classification also has place for associated intracranial features such as air in the skull (pneumocephalus) or mass lesions from bleeding or cerebrospinal fluid leakage which all has a significant role on the final decision for further investigation and treatment. The authors emphasize the role of a standardized classification because it is crucial for academic, but more importantly also for practical reasons. It offers comparison of surgical outcomes from surgeon to surgeon and it makes easier to establish the diagnosis and treatment protocols if we can compare and identically classify fractures. The beginning was not easy in the era of Harvey Cushing who did magnificent surgeries in times where no fine neuroimaging methods existed. To diagnose the underlying complex pathology he relied only on the neurological examination. A brief article from John Hopkins archive showed that by operating 23 patients half of them survived which was a good success considering the times. He made a great impact in the neurotrauma field, figuring that accuracy in the field is essential, good hemostasis is beneficial during surgery, as well as it improves postoperative healing. Another, older article showed very important facts that are also actual today. They showed that the high mortality is mostly due to increasing intracranial pressure and infection, it is important to regularly check respiration, blood pressure and the pupils of the patient which can point to leading symptoms prior to deterioration. Decompression is considered as the best option to increase the survival chances.

CONCLUSION

In the end, skull base surgery is a fascinating and rapidly growing field. Pituitary tumours are the major part of it, nowadays established ETSS and TSS show spectacular results. A meta analysis and review from Amiratti and al. showed that the ETSS approach offers less complications for pituitary adenoma operations compared to TSS. It will be interesting to see how the development will go further in the future, will new concepts be encouraged with more technical help such as robotic hands and navigation.

References:


Kirurgija baze lubanje - frakture i tumori hipofize

Sažetak


Ključne riječi: endoskopsko transsfenoidalni pristup, frakture baze lubanje, multidisiplinarnost, transseptalni transsfenoidalni pristup, tumori hipofize, mozak, traženje partnera

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