ENDONASAL ENDOSCOPIC CADAVERIC DISSECTION OF SELLAR-SUPRASELLAR REGION AND CAVERNOUS SINUS – A DESCRIPTIVE AND MORPHOMETRIC STUDY

By

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This is to certify that this thesis dissertation is by Dr Gee Teak Sheng, entitled Endonasal Endoscopic Cadaveric Dissection od Sellar-SUprasellar region and Cevernous Sinus – A Descriptive and Morphometric Study, an original work done by the candidate in Makmal Neurologi Jabatan Anatomi, Universiti Sains Malaysia and Radiology Department, Hospital Universiti Sains Malaysia during the period of June 2008 – October 2010

ABSTRACT

Introduction

Endoscopic skull base surgery has evolved in recent years from technological advancement in medical equipment related especially to the field of optical technology. The paradigm shift that occurred with the introduction of the modern rigid rod lens endoscope into the neurosurgical armamentarium saw the exponential expansion of the role of its use in pituitary tumor and endonasal skull base surgery. Due to the distinct differences between microscope and endoscope optic principles, it is important that familiarity with endonasal endoscopic anatomical landmarks be recognized by the young trainee surgeon in neurosurgery. A morphometric study of the relevant anatomy of endonasal approaches to the sellar and parasellar region is crucial to gain understanding of the anatomy of this region.

Methodology

Three asian human cadaveric heads underwent staged endonasal endoscopic dissections and anatomical landmark images were captured and morphometric measurements were attempted. Twenty Paranasal Sinus Protocol Computer Tomography of patients undergoing studies for suspected sinus disease and 20 Pituitary protocol Magnetic Resonance Imaging studies of patients being investigated for suspected pituitary diseases were selected for morphometric measurements. On the Paranasal Sinus Protocol Computer Tomography, the coronal surface area of middle and inferior chonchal bone, the whole turbinate and

the meatus were measured using Osirix software. On the coronal CT imaging the vidian canal- foramen rotundum distance were measured with Osirix software. On the Pituitary MRI the maximal anterior sphenoidal width, naso-vomer distance, chiasmal width and height, infundibulum distance, inter-carotid distance, sphenoid septum numbers, position, height and projection towards paraclival and parasellar ICA prominence, suprasellar cistern volume, pituitary area and computed volume were measured with Osirix software.

Result

On staged endonasal endoscopic cadaveric dissections; the middle turbinate, posterior choana and the sphenoid ostium were identified during the nasal and sphenoid phase. Identification of sella floor with adjacent clivus, optic and carotid protuberances and the optico-carotid recesses were documented during the sellar phase. The suprasellar and parasellar phase, the arteries identifiable were the ICA, ACA, MCA, PCom, basilar artery, PCA, superior cerebellar, and AICA. The cranial nerves III, IV, V and VI were identified. The pituitary gland with its stalk, posterior in relation to the optic chiasm was noted. Mamillary bodies and anterior floor of third ventricle were identified and opening was made in its floor to gain access into the third ventricle. The foramen of Monroe with its choroid plexus, the massa intermedia, and the superior medullary velum could be visualized with the 3 mm endoscope for intraventricular exploration.

On the paranasal sinus CT images, the inferior chonchal mean area at anterior, middle and posterior coronal levels were 0.13, 0.24 and 0.14 cm^2 on the left side and

0.15, 0.27 and 0.16 cm^2 on the right side. The whole inferior turbinate mean area at anterior, middle and posterior coronal level were 1.10, 1.39 and 1.19 cm^2 on left side and 1.02, 1.36 and 1.14 cm^2 on right side. Majority of inferior meatus area on all levels and both sides were more than 0.20 cm^2. The inferior meatus area is smallest at its anterior coronal level (mean of 0.38 cm^2 on both side) and widest at the mid coronal level (right 0.79 cm^2 and left 0.75 cm^2).

The mean middle chonchal area at vertical, oblique and horizontal coronal levels were 0.19, 0.12 and 0.20 cm^2 on the left side and 0.21, 0.14 and 0.14 cm^2 on the right side. The mean of whole middle turbinate area at vertical, oblique and horizontal coronal levels were 0.52, 0.41 and 0.47 cm^2 on the left side and 0.55, 0.46 and 0.49 cm^2 on the right side. Majority of the middle meatus studied demonstrated a surface area of more than 0.20 cm^2 and none of the concha, whole turbinate and meatus areas was significantly different when comparison were made for gender group as well as among the age groups. The mean vidian canal-foramen rotundum distance was 5.5 mm on right side and 5.3 mm on left side.

On the Pituitary protocol MRI, the mean maximal anterior sphenoidal width was 2.92 cm, naso-vomer distance 3.98 cm, chiasma width 1.48 cm, chiasma height 0.21 cm, infundibular height 0.61 cm, inter-carotid distance 1.69 cm, right, middle and left sphenoid septum heights were 1.31, 1.74, 1.27 cm respectively. Computed suprasellar cistern and pituitary volume were 1.83 and 0.44 cm^3 respectively.

Forty-five percent of sphenoid septums were in close proximity to the ICA prominence, with 75% of right sphenoid septum and 64% of left sphenoid septum pointed towards the ICA prominence.

Conclusion

Understanding the endonasal endoscopic anatomy of the sellar, suprasellar and cavernous sinus region augmented by morphometric measurements of relevant landmarks is important to improve the accuracy of the endonasal endoscopic trajectory to the midline and extended transsphenoidal approaches and this would translates into a 'safe road map' during surgery.

ABSTRAK

Pendahuluan

Pembedahan endoskopik pangkal tengkorak melalui evolusi yang ketara semenjak beberapa tahun ini sejajar dengan pembangunan alatan perubatan khasnya dalam bidang teknologi optik. Perubahan paradigma ini berlaku berikutan endoskop "rod-lens" moden diperkenalkan kepada bidang neurosurgeri dan semenjak itu peranan endoskop telah berkembang secara mendadak dalam pembedahan endonasal pituitary dan pangkal tengkorak. Disebabkan prinsip optik antara mikroskop dan endoskop adalah amat berbeza, maka adalah penting untuk pelatih neurosurgeri membiasakan diri kepada mercu tanda anatomi endonasal endoskopi. Kajian morfometrik anatomi berkenaan bagi mengikuti pendekatan secara endonasal kepada kawasan sellar-parasellar amatlah penting untuk pemahaman anatomi kawasan tersebut.

Kaedah

Tiga mayat manusia berketurunan asia telah melalui pembedahan endonasal endoskopi secara berperingkat dan imej mercu tanda anatomi telah diambil dan pengukuran morfometrik telah dijalankan. Dua puluh tomografi komputer protokol paranasal sinus (CT PNS) dan dua puluh pengimejan resonans magnetik protokol pituitari telah dipilih untuk pengukuran morfometrik. Pada CT PNS, luas permukaan koronal tulang konka, keseluruhan turbinate dan meatus bagi turbinat inferior dan tengah telah diukur dengan perisian Osirix. Pada Koronal CT jarak vidian kanal – foramen rotundum diukur dengan perisian osirix. Pada MRI Pituitari, lebar maksima sfenoid, jarak naso-vomer, lebar dan tinggi kiasma, jarak infundibulum, jarak antara karotid, serta bilangan, posisi, tinggi dan unjuran sfenoid septum kepada paraklival

dan parasellar ICA, isipadu suprasellar sisterna, serta luas kawasan dan isipadu kiraan pituitary telah diukur menggunakan perisian Osirix.

Keputusan

Semasa pembedahan mayat endonasal endoskopik secara berperingkat, turbinat tengah, koana dan sfenoid ostium telah dikenalpasti semasa fasa nasal dan sfenoid. Pengenalan lantai sella dengan klivus, benjol optik dan karotid serta ceruk optiko-karotid telah didokumentasikan dalam fasa sellar. Semasa fasa suprasellar dan parasellar, arteri yang dikenalpasti ialah ICA, ACA, MCA, PCom, Arteri Basilar, PCA, Superior cerebellar dan AICA. Saraf kranial III, IV, V dan VI juga telah dikenalpasti. Kelenjar pituitari bersama tangkainya yang berada dibelakang optik kiasma telah dicatatkan. Jasad mamillari dan lantai hadapan ventrikel ketiga telah dikenalpasti dan pembukaan dibuat pada lantai berkenaan bagi memdapatkan laluan masuk ke ventrikel ketiga. Foramen Monroe bersamaan pleksus koroid, massa intermedia dan unggul meduler bahagian belakang langit-langit (superior medullary velum) dapat divisualisasikan dengan endoskop 3 mm sewaktu eksplorasi ventrikel.

Pada imej PNS CT, purata luas kawasan tulang konka turbinat inferior di tahap depan , tengah dan belakang koronal adalah 0.13, 0.24 dan 0.14 cm^2 di bahagian kiri dan 0.15, 0.27 dan 0.16 cm^2 di bahagian kanan. Purata luas kawasan keseluruhan turbinat inferior di tahap depan, tengah dan belakang koronal adalah 1.10, 1.39 dan 1.19 cm^2 di bahagian kiri dan 1.02, 1.36 dan 1.14 cm^2 di bahagian kanan. Majoriti luas kawasan meatus inferior pada semua tahap dan kedua dua bahagian adalah melebihi 0.20 cm^2. Luas meatus inferior adalah paling sempit ditahap depan (purata 0.38 cm^2 pada kedua bahagian) dan paling luas ditahap tengah (kanan 0.79 cm^2 dan kiri 0.75 cm^2).

Luas purata tulang konka turbinat tengah pada tahap menegak, condong dan melintang adalah 0.19, 0.12 dan 0.20 cm^2 di bahagian kiri dan 0.21, 0.14 dan 0.14 cm^2 di bahagian kanan. Luas kawasan keseluruhan turbinate tengah pada tahap menegak, condong dan melintang adalah 0.52, 0.41 dan 0.47 cm^2 di bahagian kiri dan 0.55, 0.46 dan 0.49 cm^2 di bahagian kanan. Majoriti meatus tengah yang dikaji mempunyai keluasan melebihi 0.20 cm^2 dan tiada perbezaan signifikan pada keluasan tulang konka, keseluruhan turbinat dan meatus semasa bandingan dibuat antara kumpulan gender mahu pun dalam kumpulan usia. Purata jarak vidian kanal-foramen rotundum adalah 5.5 mm pada bahagian kanan dan 5.3 mm pada bahagian kiri.

Pada protokol MRI pituitari, purata lebar maksima sphenoid adalah 2.92 cm, jarak naso-vomer 3.98 cm, lebar chiasma 1.48 cm, tinggi kiasma 0.21cm, tinggi infundibular 0.61 cm, jarak antara karotid 1.69 cm, tinggi septum sphenoid bahagian kanan, tengah, dan kiri masing-masing adalah 1.31, 1.74, 1.27 cm. isipadu kiraan komputer bagi sisterna suprasellar dan pituitari masing-masing adalah 1.83 dan 0.44 cm^3.

Empat puluh lima peratus daripada septum sfenoid adalah berdekatan dengan tonjolan ICA. Sebanyak 75% dari septum sfenoid bahagian kanan dan 64% bahagian kiri mengunjur ke arah tonjolan ICA.

Kesimpulan

Pemahaman anatomi endonasal endoskopi untuk kawasan sellar, suprasellar dan kavernius sinus ditambah dengan pemahaman morfometrik mercu anatomi yang relevan adalah penting bagi meningkatkan ketepatan trajektori garis tengah endonasal endoskopi serta pendekatan 'extended transphenoidal'. Ini akan dapat diterjemahkan sebagai "peta jalan yang selamat" semasa pembedahan

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LEGEND:

1. ACA : Anterior cerebral artery
2. AICA : Anterior inferior cerebellar artery
3. AIS : Anterior incisural space
4. BA : Basillar artery
5. CI : Confidence interval
6. CN III : Oculomotor nerve
7. CN IV : Trochlear nerve
8. CN V : Trigeminal Nerve
9. CN VI : Abducens nerve
10. CS : Cavernous sinus
11. CSF : Cerebral spinal fluid
12. CT : Computer tomography
13. ICA : Internal carotid artery
14. IT : Inferior turbinate
15. MCA : Middle cerebral artery
16. MIS : Middle incisural space
17. MRI : Magnetic resonance imaging
18. MT : Middle turbinate
19. NS : Nasal septum
20. OCR : Opticocarotid recess
21. PCA : Posterior cerebellar artery
22. PCom : Posterior communicating artery
23. PNS : Paranasal sinus
24. SCA : Superior cerebellar artery
25. S.D : Standard deviation
26. SO : Sphenoid ostium
27. VR : vidian canal- foramen rotundum distance

CHAPTER 1: INTRODUCTION

"But we keep doing more, finding more. Each advance redefines what we do"

Albert L. Rhoton Jr.

Neuroendoscopy was introduced a century ago by L'Espinase, a urologist, who attempted endoscopic coagulation of choroid plexus for the treatment of hydrocephalus in 1910 (Teo, C., 2005). Since then endoscopy has revolutionized the way we view various anatomical spaces in particular the bladder and urinary tract, abdominal cavity (through laparoscopy), ventricles (neuroendoscopy), and in recent time endoscopic spine surgery. Advancement in coaxial illumination, optics of the lens system and image capture technology through computer software specifically developed for the purpose has revolutionized the diagnosis and endoscope assisted management of diseases in these anatomical regions.

Neuroendoscopy is now an established method to treat a wide spectrum of neurosurgical pathologies including hydrocephalus, intracranial and arachnoid cyst, CSF fistula repair, basal meningoencephalocele besides transphenoidal surgery for various tumors such as pituitary adenoma, chordoma and meningioma and Rathke's Cyst (Jho, H.D., 2001a; Fatemi, N., *et. al.,* 2008a; Fatemi, N., *et. al.,* 2008b Cappabianca P., *et al.*, 2002) .

The history of the transphenoidal approach to the sella turcica had a humble beginning with the use of simple equipment like Cushing's head light. Later Norman Dott introduced his lighted speculum retractor (Doglietto, F., et al., 2005). The safety of this approach multiplied many times with the arrival of serial generations of operative microscopes and the current modern endoscope.

The principle of optics of the microscope has few distinct disadvantages such as the problem of a 'narrowing conical view' with decreasing angle of visualization upon approaching the target. This narrowing tunnel vision is worsened with the application of speculum which further decreases the width of the vision. The speculum also necessitates the usage of bayoneted equipment in order to avoid conflict of visualization of the target area by the introduction of various instruments during surgery. The advantages of the microscope are represented by the 'strict' midline trajectory to the sellar region and easy intraoperative 'rostrocaudal' orientation using the image intensifier. Most neurosurgeons trained in the eighties and nineties would swear by the latter. However this midline visualization presents limitation of working ability in the lateral compartment of the sphenoid sinus.

These disadvantages encountered during the microscope era have been solved by the introduction of the modern neuroendoscope with better illumination and excellent close up view of the target that magnify as the neuroendoscope approaches the target. The availability of multiple angles telescope is an added advantage not feasible in the microscope. With these advances the endoscopic transsphenoidal surgery has evolved from a per case basis surgery into a standard operative procedure for most pituitary tumors in recent years. With increased surgical expertise the description and usage of expanded endonasal approaches are being used to treat planum sphenoidale meningioma, clival chordoma, skull base AVM and ventral craniovertebral junction pathologies (Kassam, A.B., *et al.*, 2005; Cavallo, L.M., *et al.*, 2009; Kassam, A.B., *et al.*, 2007; Zhang, Q., *et al.*, 2008; Fatemi, N., *et al.*, 2008b).

The midline skull base approach to relevant pathologies and current surgical scenario which favours minimally invasive approaches will push neurosurgery practitioners into mandatory acquiring of this all important endoscopic knowledge and training.

The endonasal endoscopic anatomy of the midline skull base is vastly different from the traditional understanding of transcranial microdissection of the region. The challenges faced in dissection of these regions require a detailed understanding of the endoscopic anatomy of a region where all the vitals neurovascular-endocrinology structures are compact and in close proximity. Equally important is for the trainee to get familiar with the different endoscope system, dissecting equipment and its set up. Familiarity with the system and acquisition of the hand-eye coordination required is essential for any endoscopic surgery. Expanded approaches require understanding and co-operation between two surgeons of two discipline in Otorhonolaryngology and Neurosurgery who handle such a small delicate operative field (Castelnuovo, P., 2006). This can only be acquired through a meticulous participation in endonasal endoscopic dissection of sellar region. Thus cadaveric dissection provides a good platform in acquiring such understanding. As Dr Jho HD (Jho, H.D., 2001b) a senior in this field would say "the learning curve is rather steep" and the possibilities of expanded transphenoidal surgery in lesion extirpation have expanded in the past two decades.

This introduction forms the basis of the current study, with the hope of having a skull base lab available to us, the junior neurosurgery practitioner to enhance our skull base surgical horizon. An animal model in ungulates developed in the department is a good starting point for beginner (Pal, H.K., 2007).

CHAPTER 2: LITERATURE REVIEW

"The performance becomes progressively simplified by the combination of suggestion and experience of many" *Harvey Cushing.*

2.1 The history of endoscope

The word endoscope literally means 'looking inside'. It has become a useful surgical tool to look into various anatomical spaces. In recent times it has been used extensively in urology, laparascopic surgery, functional sinonasal surgery and neurosurgery (ventriculosopy, spinal surgery and skull base surgery)

The modern neuroendoscope has come a long way evolving from a rather 'simplistic' device to current form which is capable of providing excellent illumination and excellent quality of image including equipment which enables image and video recording for future reviews and teaching purposes.

The first endoscope could be credited to Philip Bozzini, a German physician when he presented the "Lichtleiter"- The Light Conductor in 1804. Lichtleiter was a simple device consisting of an eyepiece, a container for a candle and a mirror to reflect the light through a tube. It was purchased by the Austrian Emperor during a scientific conference in Frankfurt and was used in the University of Vienna. However, the Lichtleiter did not received good reviews as the visualization was less than satisfactory and at times it caused painful burns in the patients being examined (Doglietto, F., *et. al.,* 2005).

The next breakthrough in the development of endoscope came 75 years later in 1879. A German urologist, Dr Maximilian Nitze and a Vienna instrument maker, Joseph Leiter, invented the Nitze-Leiter cystoscope. The viewing device was made from telescope lens coupled with electric heated platinum wire as illumination source. This platinum heated wire needed a cooling system and occasionally it also caused burn wound. When Thomas Edison invented the incandescent light bulb, this was used to replace the platinum heated wire as the light source. Dr. Nitze took the first endoscopic picture in urology with this device. (Doglietto, F., *et. al.,* 2005).

Endoscope was a novel device at that time, the first endoscope guided laparascopy was done by Georg Kelling, a German physician, on a dog in 1901. In the same year, Helschmann A examined the sinonasal region with endoscope and two years later, in 1903 he performed endoscopic sinus surgery for patient with sinonasal chronic inflammation.

The application of endoscope was subsequently expanded for viewing the thoracic and abdominal cavities. In 1910, Christian Jacobaeus from Stockholm, Sweden perform the first endoscope-guided thoracoscopy and laparascopy in humans.

It was also in 1910 that the endoscope was introduced into the cranial cavity by Victor Darwin Lespinasse, a urologist from Chicago USA. He performed endoscopic intraventricular coagulation of choroid plexus in an attempt to treat hydrocephalus in two children with little success, the first died postoperatively while the second lived for 5 years (Doglietto, F., *et. al.,* 2005).

As the ventricular diversionary shunt systems gained more and more success, ventriculoscopic treatment of hydrocephalus took a dip. The surgical treatment for