THE RELEVANT ANATOMICAL PARAMETERS OF THE INTERNAL CAROTID ARTERY AND OPTIC NERVE IN RELATION TO LATERAL WALL OF SPHENOID SINUS – A MRI STUDY

BY

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To

My beloved husband, Khairul Ziad Zahari

My treasures; Wafry , Wafaa and Muizz

Not forgetting my parents .

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In the name of Allah , the most gracious , the most merciful.

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ABBREVIATIONS

CSF	cerebrospinal fluid
FCAT	Federative Committee on Anatomical Terminology
HUSM	Hospital Universiti Sains Malaysia
IFAA	International Federation of Associations of Anatomists
MRI	Magnetic Resonance Imaging
ICA	Internal carotid artery
CT	Computed tomography
ENT	Ear nose and throat
FESS	Functional endoscopic sinus surgery
Mm	Millimeter
MDCT	Multi detector computed tomography
SD	Standard deviation
TR	Time for repetition
TE	Time for echo
US	United States

ABSTRAK

TAJUK : Parameter berkaitan anatomi bagi arteri karotid interna dan saraf optik dengan dinding lateral rongga sfenoid – suatu kajian MRI.

LATARBELAKANG : Secara umumnya, surgeri melibatkan rongga sfenoid dan FESS mempunyai risiko dan kadar komplikasi yang rendah. Walaubagaimanapun , surgeri tersebut adalah mencabar secara teknikalnya kerana hubungan yang kompleks melibatkan saraf dan salur darah di antara rongga sfenoid , iaitu melibatkan arteri karotid interna dan saraf optik.Kajian ini menggambarkan anatomi radiologi yang berkaitan rongga sfenoid dan struktur tersebut.

OBJEKTIF: Untuk mengkaji parameter anatomi bagi arteri carotid interna dan saraf optic yang berkaitan dengan rongga sfenoid berdasarkan protokol MRI kelenjar pituitari yang diubahsuai.

TATACARA: Di dalam kajian prospektif ini yang melibatkan 30 pesakit , dijalankan dari Disember 2009 hingga August 2010, protokol MRI kelenjar pituitari yang diubahsuai telah dijalankan. Imej sagittal , axial dan coronal di dalam ' fat suppression sequences' telah dijalankan menggunakan 'slice thickness' 1.7 mm dan 'spacing ' 0.5 mm. Jarak di antara kedua arteri karotid interna telah diukur pada pandangan koronal dan aksial , jarak yang paling kecil dan besar serta lokasinya telah dipastikan bagi setiap pesakit. Indentasi saraf optik dan arteri karotid interna kepada

rongga sfenoid telah ditentukan. Hubungkait di antara indentasi arteri karotid interna dan umur , jantina serta jenis pengudaraan rongga sfenoid juga ditentukan.

KEPUTUSAN : 'Pengudaraan' jenis sellar merupakan yang paling banyak dijumpai (66.7%), diikuti jenis 'post sellar' (26.7%) dan jenis 'pre sellar' (6.7%). Tiada jenis 'concha' ditemui. Jarak paling kecil adalah 7.00 ± 4.66 mm (pandangan koronal) and 6.30 ± 4.70 mm.(pandangan aksial). Majoriti terletak di segmen 'cerebral/supraclinoid' (73.3%) dan 'cavernous (26.7%). Jarak paling besar adalah 28.20 ± 5.90 mm (pandangan koronal) and 28.43 ±5.7 mm (pandangan aksial). Daripada jumlah ini, 46.7% terletak di segmen 'cavernous' ,'petrous' (40.0 %) dan 'cerebral/supraclinoid' (13.3%). Indentasi saraf optik dan arteri carotid interna adalah 46.7% dan 66.7% masing-masing. Terdapat hubungkait di antara jenis pengudaraan rongga sfenoid dengan indentasi arteri karotid interna (p = 0.003). Tidak terdapat hubungkait di antara pengudaraan rongga sfenoid dengan umur dan jantina.

KESIMPULAN : Peratusan indentasi arteri carotid interna dan saraf optik ialah 46.7% dan 66.7% masing-masing. Jarak paling kecil di antara arteri karotid interna kanan dan kiri adalah 6.30mm , paling banyak terletak di segmen 'cerebral/supraclinoid'. Kedua-dua variasi anatomi ini mendedahkan struktur tersebut kepada kecederaan dan perlu dimaklumkan kepada pakar bedah sebelum pembedahan.

ABSTRACT

TOPIC: The relevant anatomical parameters of the internal carotid artery and optic nerve in relation to lateral wall of sphenoid sinus – a MRI study.

OVERVIEW: Sphenoidal surgery and FESS surgery generally has low risk and complications rate. However the surgeries are technically challenging due to complex relationship of neurovascular structures namely internal carotid artery (ICA) and optic nerve . This study illustrates radiological anatomy relationship of the sphenoid sinus with these neurovascular structures.

OBJECTIVE: To evaluate certain anatomical parameters of internal carotid artery and optic nerve in relation to the lateral wall of sphenoid sinus based on modified MRI protocol of pituitary gland.

METHODOLOGY: In this prospective study of 30 patients carried out from December 2009 until August 2010, the following modified MRI protocols of pituitary were performed. Sagittal, axial and coronal view in fat suppression sequences using slice thickness of 1.7 mm and spacing of 0.5 mm were performed. The smallest and largest distance between both ICA were measured on coronal and axial views , and their respective locations were determined for each patient. Indentations of optic nerve or internal carotid artery on sphenoid sinus were also evaluated. Sphenoid sinus

pneumatisation pattern was studied. Association between internal carotid artery indentation with age, gender and types of sphenoid sinus pneumatisation were determined.

RESULTS: Most common type of sphenoid sinus pneumatisation was sellar type (66.7%), followed by post sellar type (26.7%) and presellar type (6.7%). No conchal type noted. The mean of smallest distance between right and left internal carotid arteries were (7.00 ± 4.66 mm (coronal view) and 6.30 ± 4.70 mm (axial view); in which majority (73.3%) located in cerebral/ supraclinoid segment and 26.7% in cavernous. The mean of largest distances were 28.20 ± 5.90 mm (coronal view) and 28.43 ±5.7 mm (axial view). Of this, 46.7% located in cavernous segment, petrous (40.0 %) and cerebral/supraclinoid (13.3%). Indentations of optic nerve and internal carotid artery were noted in 46.7% and 66.7% of patients respectively. There was significant association between type of sphenoid sinus pneumatisation with internal carotid artery indentation ($p = 0.003$). No statistically significant association between internal carotid artery indentation with age and gender.

CONCLUSION: Internal carotid artery and optic nerve indentations were noted in 46.7% and 66.7% of the patients respectively in our study. The smallest distance between right and left internal carotid artery can be as narrow as 6.30 mm, most commonly located in the cerebral/supraclinoid segment. Both these anatomical variants predispose the structures for injury and should be acknowledged to the surgeon before the surgery.

INTRODUCTION

1.0 INTRODUCTION

Sphenoid sinus is the most posterior paranasal sinuses, located on either side of the midline at the skull base. O.E Van Alyea was once regarded this sinus as 'neglected sinus 'in 1941 due to its anatomical location and difficult accessibility. However since 1980's this neglected sinus has gaining its popularity due to the development of endoscopic endonasal sinus surgery.

In 1990, the functional endoscopic sinus surgery has gained its strong footings due to the wide acceptance among the rhinologist throughout the world. Endoscopes with various angulations had really familiarised the rhinologists' work in the sphenoid sinus. The interest was deepened when the two interface disciplines, rhinologist and neurosurgeons realised the superiority of endoscopic viewing and manipulation over microscopic vision during trans sphenoidal surgeries. Entrance to the sellar and para sellar regions under direct vision and magnification has tempted to explore the combined endoscope skull base working by the two subspecialties.

In last ten to fifteen years many variations of surgical approaches have been evolved for pathology involving sphenoid sinus, sella and parasellar region namely trans nasal , trans ethmoid , sublabial, trans septal etc. Endoscopic direct trans nasal trans sphenoidal approach for the pathology of above mentioned region including infection and neoplasm is gaining fast acceptance among the endoscopic rhino neurosurgical skull base surgeons. Even though this surgery is considered relatively safe, fatal complications are being reported.

Furthermore with the advancement of trans sphenoidal surgery, its use has been extended not only for pathology involving sellar and parasellar region, but it is also being used for lesions at the anterior skull base fossa, cavernous sinus, clivus, petroclival region and even posterior fossa. This implies an increased risk for complication (Jho *et al* ,1999).

Technically, surgery involving this region is difficult due to the complex neurovascular relationships of the sphenoid sinus. Two neurovascular structures located at both supero lateral walls of the sinus are the internal carotid artery and the optic nerve. These structures are very important and significant with regard to trans sphenoidal surgery as well as functional endoscopic sinus surgery (FESS).

Both these structures can indent with bony dehiscences in the sphenoid sinus lateral wall, thus making them vulnerable and prone to injury during the surgery. The internal carotid arteries can converge excessively with the distance between them reduced to as narrow as 4 mm. A rare variant of internal carotid artery reported in literature, known as 'kissing carotid artery'. In this variant, there is medial deviation of both right and left internal carotid arteries, which almost touching each other (Filho *et al* , 2007) . In this condition, the trans sphenoidal surgery is contraindicated.

Incidence of vascular injuries to internal carotid artery ranges from 0.24% - 2% (Teramoto *et al*, 2002 and Ciric *et al*, 1997). The resultant complications include carotid cavernous fistula, false or mycotic aneurysms, post operative vasospasm and vascular occlusion.

Apart from internal carotid artery, optic nerves can also being injured during the surgery which can result in visual loss. Optic nerve injury or damage is a serious complication of sphenoidal surgery. The optic nerve indentation into the sphenoid sinus is one of major contributory factors for the injury. (Dessi *et al*, 1994).

The incidence of complications for transphenoidal surgeries has reduced with the advancement of techniques and preoperative imaging modalities. The incidence of operative mortalities were 5.6% in the initial era of sphenoidal surgery from 1910 to 1925 , and later the number has reduced in a later study by Habila *et al* (2005) , in which they found low morbidity with no operative mortality among 300 transphenoidal surgeries. One of the possibility for the improvement of morbidity and mortality rate of the surgery is increasing awareness among the surgeon regarding anatomical relationship of the sphenoid sinus through various studies during these period (Bademci *et al* 2005 ,Davoodi *et al* 2007 , Hatipoglu *et al* 2009, Hewaidi *et al* 2008, Ossama *et al* 2008, Siricki *et al* 2009 , Tan *et al 2007*).

On imaging, most of the studies were done based on CT scan. Very few studies are available in literatures based on MRI. On CT scan, both internal carotid artery and optic nerve are identifiable as indentations into the sphenoid sinus lateral wall depending on degree of sphenoid sinus pneumatisation. However on MRI, there is better soft tissue delineation. Literature reviews revealed many advantages of MRI in evaluation of this region, which will be evaluated further in this study.

This study is intended to study the anatomy of internal carotid artery and optic nerve in relation to sphenoid sinus wall based on MRI, particularly to establish reference for smallest and largest distances between both internal carotid arteries and its location.

Apart from that, we also want to study the percentage of indentation of both internal carotid artery and optic nerve to sphenoid sinus, in which both conditions can increase the risk of neurovascular injury. This study is important since only one published study on sphenoid sinus and neighbouring structures in our country done by Abdullah BJ *et al*, 2001. Due to diverse findings of the studies regarding sphenoid sinus and neighbouring structures with one of the contributory factor is racial variations (Hewaidi *et al* 2008 and Sareen *et al* 2005), we think it is important to conduct a similar study in our country using different imaging modalities (MRI). We hope that our study will help the surgeons to minimise the complications of internal carotid artery and optic nerve injury during FESS and trans sphenoidal surgeries.

LITERATURE

REVIEW

2.0 Literature review

2.1 Anatomy of sphenoid sinus

The sphenoid sinuses consist of two large irregular cavities which contained within body of sphenoid bone. Both the cavities are usually separated by an asymmetrical septum. Sphenoid sinus was described as the 'forgotten sinus' or 'neglected sinus' in 1941 by O.E Van Alyea due to difficult accessibility and its anatomical location. It is the most inaccessible paranasal sinuses and is surrounded by significant anatomical structures like the orbit and its content, cavernous sinus and internal carotid artery, and the anterior cranial fossa (Van Alyea, 1941). The sinus also separates nasal cavity with pituitary gland (Fujii *et al*, 1979).

The precursor to the sphenoid sinus emerges in the fourth month of fetal development as an evagination of the posterior nasal capsule into the sphenoid bone (Baskin *et al*, 2003). At birth, the sphenoid sinuses are present as minute cavities. The pneumatisation starts at 3 years of age (Ryan, 2004) and the main development of the sinuses takes place after puberty. Pneumatisation progresses in an inferior posterolateral direction (Anthony *et al*, 1993). In early life, the air cavity within the sinus extends to presellar region and later extends to the area below and behind sella turcica. The pneumatisation also may extend into the greater wing of sphenoid or clinoid processes (Ryan, 2004). It reaches its full size in adolescence (Fujii *et al*, 1979). Radiologically, pneumatisation of sphenoid sinus may be shown as early as 2 years old on high resolution CT scan (Anthony *et al*, 1993).

Hammer *et al* , 1961 has described 4 types of pneumatisation ; conchal , pre sellar , sellar and post sellar (Hammer *et al* , 1961 cited in Cesar *et al* , 2004).

Conchal type represents small sphenoid sinus with minimal pneumatisation, without association of sella turcica. The description of pre sellar, sellar and post sellar type of sphenoid pneumatisation was illustrated in Figure 2. Two imaginary lines were drawn perpendicular to sphenoidal plane in mid sagittal view of the brain. Line A was drawn anterior to the sella turcica at the level of the tuberculum sella, and Line B, at the posterior clinoid process.

Pre sellar type represents the sinus cavity that does not extend posteriorly the vertical plane of tuberculum sella, it is tangent to Line A (Figure 2). Sellar pneumatisation of the sphenoid sinus is related to the anterior wall and floor of sellar turcica. It is limited by line B. Post sellar pneumatisation of the sphenoid sinus represents pneumatisation that extends beyond Line B, perpendicular to the posterior clinoid process.

During surgery, a highly pneumatised sphenoid sinus may cause distortion of the anatomic configuration of the sinus and may attenuate the bone over the lateral wall (Siricki *et al*, 2000). In this condition, the optic nerve and carotid artery are prone to a greater risk for injury.