Microsurgical Anatomical Study of the Anterior Communicating Artery Complex

REN Wei-dong[1], LIU Chun-mei[2], CHI Huan-fang[1△]

(1 Department of Anatomy, Qingdao University Medical College,Qingdao, Shandong, 266021, China;

2 Operating Room of Mengyin County People's Hospital, Mengyin, Shandong, 276200, China)

ABSTRACT Objective: To investigate the anatomy structure and adjacent vessels by investigating the anterior communicating artery complex and its perforating branches under an surgery microscope, in order to, to provide anatomical datas for anterior communicating aneurysms. Method: A total of 15 adult cadaveric heads (30 cerebral hemispheres) fixed with formalin were used, red latex was injected into internal carotid artery. Anterior communicating artery complexes were dissected, detected by surgery microscope. The results were analyzed with SPSS 17.0 statistical software. The lengthes, diameters and variations of the anterior cerebral artery(ACA) A1 segment, A2 segment, anterior communicating artery (AComA), Heubner recurrent artery(HRA), perforating branches of A1 segment and AcomA were measured. Result: There were no statistically significant differences between two sides of A1 segment in length and diameter. HRA, perforating branches of A1 segment and AComA should be carefully recognized and protected during the operation on anterior communicating aneurysms. The middle 1/3 of A1 segment which had less perforating branches was the best position for temporary occlusion during the operation on anterior communicating aneurysms. It is difficult to distinguish AComA in cerebral angiography. Conclusion: The anterior communicating artery complex was regarded as the most complex. Being familiar with the anatomy of the anterior communicating artery complex and the perforating branches enabled neurosurgeons to handle the diseases in this area efficiently.

Key words: Anterior communicating Artery complex; Anterior communicating artery; Anterior cerebral artery; Heubner recurrent artery; Microanatomy

Chinese Library Classification (CLC): R739.4, R322.8 Document code: A

Article ID:1673-6273(2011)02-233-04

Introduction

Anterior communicating artery complex was the predilection site of intracranial aneurysm [1]. During an operation, the exposure of operative field was mainly relied on selecting suitable approach, released cerebrospinal fluid and pulled of adjacent anatomic structures. But it became difficult in recognizing blood vessels and protecting branches if the exposure of operative field was blocked when the aneurysm was huge or there was hematoma owing to the rupture of aneurysms. Up to now, duing to the extensive use of surgery microscope, neuroendoscope and intervention therapy, there were new requirements for the anatomy of anterior communicating artery complex. This study dissected 15 brain specimens and studied the anterior communicating artery complex and its perforating branches in order to bring valuable references for clinical surgery.

1 Material and Methods

1.1 Brain specimens

15 adult (9 males and 6 females) cadaveric heads fixed with formalin were provided by the Department of Anatomy, Medical College of Qingdao University. All of specimens were perfused with red latex through both sides of internal carotid artery .

1.2 Laboratory equipments and instruments

Corder ASOM-5 surgery microscope (Chengdu Corder Optics & Electronics Co, Ltd) microsurgery Instruments, slide calliper rule, Canon IXUS 960 IS digital camera.

1.3 Data acquisition

After craniotomy and removing part of frontal lobe, the morphology of anterior communicating artery complex and its perforating branches were observed by microscope. The adjacent structures were record. Then the brains were token out and the lengthes and diameters of the A1 and A2 section of ACA, AComA, HRA , perforating branches of ACA and AComA were measured by microscope measurement system and slide calliper rule.

1.4 Statistic methods

The results were analyzed by SPSS 17.0 statistical software(test, $p<0.05$) and the data was shown as mean± standard deviation.

2 Results

2.1 The proximal anterior cerebral artery (A1 segment)

A1 segment arose from the bifurcation of internal carotid artery at the medial end of sylvian fissure, then coursed under the medial olfactory striate and anterior perforated substance, above the optic nerve or chiasm and it terminated at anterior communicating artery. There were 29 A1 segments in the 30 cerebral hemi-

Author introduction: REN Wei-dong , (1975-) , male, master , Mainly engaged in clinical applied anatomy, telphpne: 13475806769,
E-mail: renweidongdong@126.com
△Corresponding author: CHI Huan-fang,
E-mail: hfchi9200@163.com
(Received:2010-10-03 Accepted:2010-10-30)

spheres, and one right A1 segment of which was absent (its A2 segment rose from the left A1 segment). The diameter of A1 segment on both sides was equal (within variation of 0.1 mm) in 5 brain specimens, left-sided A1 segment was greater than that of the right in 6 brain specimens, right-sided A1 segment was greater than the left in 4 brain specimens. There were no statistically significant differences between two sides (P=0.862>0.05). Data of A1 segment is shown in table 1.

Table 1 The length and diameter of A1 segment

	Length(mm)	* Diameter(mm)
Left side	13.43± 1.55	2.34± 0.60
Right side	12.19± 4.10	2.09± 0.81
Both sides	12.81± 3.11	2.22± 0.71

* The diameter was the outside diameter of the vessel 1mm away from the originating point.

2.2 Anterior communicating artery

AComA was a bridging vessel, connecting bilateral A1 segments and lied above the optic chiasm. Yasargil MG sorted AComA into simple type and complex type[2]. The simple type had only one AComA connected the ACAs of both sides. The complex ones contained two or three AComA s, or had AcomA as fenestrated, netlike, looped, bridged. In this study, the diameter of AComA ranged from 0.53 mm to 2.96 mm, (average,1.38± 0.86 mm), the length of AComA ranges from 0 mm to 5.45 mm, (average , 2.93± 1.22 mm). Simple type AcomAs were present in 11 brain specimens (73.33%), and complex type AComAs were present in 4 brains (26.67%).

2.3 Distal anterior cerebral artery(A2 segment)

The segment of ACA between the anterior communicating artery and the rostrum of the corpus callosum was referred to as A2 segment. Yasargil MG sorted A2 segment into three types: single A2 segment type(2.0%), two A2 segments type(89%), three A2 segments type (9.0%)[2]. The central A2 segments of the three A2 segments type was also called median corpus callosum artery, which rose from the anterior communicating artery frequently. In this study, the diameters of left A2 segments (1 mm away from the beginning) averaged 2.08± 0.25 mm, right side averaged 2.04± 0.27 mm; and the diameters of both sides A2 segments averaged 2.06± 0.26 mm. There was only one brain specimen contained three A2 segments in 15 head specimens.

2.4 Heubner recurrent artery

HRA was the largest artery arising from lateral wall of A1 segment or the proximal 1 mm of the A2 segment. HRA returned back immediately along its parent artery (ACA) and passed above the carotid bifurcation, entered anterior perforated substance. In this study, 48 HRAs were found in the 30 cerebral hemispheres. All of these HRAs, 20 (41.67%)originated at the level of AComA, 5 (10.42%) HRAs arose from A1segment and 23(47.92) originated from A2 segment. Each of the 30 hemispheres contained HRA from 1 to 3 in number, 15 (50%) hemispheres contained 1 HRA, 12 (40%) hemispheres had 3 HRA, 3 (10 %) hemispheres contained 3 HRA. HRA pursued a long way to the anterior perforated substance, in this study , 22 (45.83%)coursed anterior to the A1 segment , 20 (41.67%)coursed superior to the A1 segment, 4 (8.33%)coursed posterior to A1. Data of HRA was shown in table 2.

Table 2 The number, length and diameter of HRA

	Number	# Length(mm)	* Diameter(mm)
Left side	1.66± 0.72	18.97± 7.37	0.55± 0.19
Right side	1.53± 0.64	19.25± 5.37	0.62± 0.23
Both sides	1.60± 0.67	19.10± 6.42	0.58± 0.21

The length was the part out of the cerebral parenchyma, * The diameter was the outside diameter of the vessel 1mm away from the originating point.

2.5 The perforating branches of A1 segment

A1 segment had many perforating branches (except for HRA) from its postero-medial and inferior wall. In this study, 101 perforating branches originated from 29 A1 segments, among them 66 (65.35%)originated from the proximal 1/3 of A1 segment , 19 (18.81%)originated from middle 1/3 segment, and 16(15.84%)originated from the distal 1/3 segment. The number of perforators varied between 2 and 8, the length out of the cerebral parenchyma ranged between 2.27 and 9.38 mm , and the diameter 1 mm away from the originating point ranged between 0.11 and 0.65 mm. Datas of A1 perforating branches were shown in table 3.

Table 3 The number, length and diameter of A1 perforating branches

	Number	# Length(mm)	* Diameter(mm)
Left side	3.40± 1.59	5.73± 1.67	0.28± 0.11
Right side	3.33± 1.39	5.78± 1.61	0.29± 0.12
Both sides	3.37± 1.47	5.72± 1.63	0.28± 0.12

was the length of the part out of the cerebral parenchyma,* was 1mm away from the originating point.

2.6 The perforating branch of AComA

The perforating branches of AComA originated from the posterior and inferior wall of anterior communicating artery normally, and coursed posttero-superiorly in the cistern of lamina terminalis, terminated at hypothalamus. There were 33 perforating branches of AComA in 15 brain specimens (occurrence rate was 100%). The number of branches ranged between 1 and 4 (average,2.20± 0.86) mm ; Diameter (1mm away from the originating point) ranged from 0.11 to 1.17 mm, (average, 0.43 ± 0.24 mm); The length (out of the cerebral parenchyma) ranged from 5.96 to 11.73 mm (average, 9.31± 1.51 mm).

3 Discussions

3.1 Hypoplasia of A1 segment and anterior communicating aneurysm

Gao SL [3] concluded that the normal diameter of A1 segment was 1.0～3.0 mm , < 1.0 mm in diameter was hypoplasia, < 0.5 mm was severe hypoplasia . In the study, all the 30 A1 segments were normal. Stehbens reported the A1 segment was the favorite site on the circle of Willis for hypoplasia, and it was the only anatomic variant that correlates with the location of cerebral aneurysm [4]. 85% anterior communicating aneurysms were relative to A1 segment hypoplasia. Rhoton reported that aneurysm usually occurred in the setting where one A1 segment was hypoplastic and the dominant A1 gave rise to both A2s [5]. Brandtreported that the diameter of left A1 was greater than that of the right, which were (3.2± 0.09) mm and (2.71± 0.09) mm respectively [6]. Huang Q and Ru ML had similar conclusion by way of anatomy [7,8]. In this study the diameter of left A1was 2.34± 0.60mm and the right was 2.09± 0.81 mm, and there were no statistically significant differences between the two sides (P=0.341>0.05). The length of left A1 was 13.43 ± 1.55 mm, and the right was 12.19 ± 4.10 mm, there were no statistically significant differences between the two sides (P=0.283 >0.05).This result concluded from the specimens unscreened disagreed with above-mentioned outcomes.

3.2 Path of HRA and clinical significance

HRA was first described by the Heubner in 1874, and in 1909, Aitken named it Heubner artery. In 1920, Sellshea added a word Recurrent, called it Heubner recurrent artery [9]. HRA was unique among arteries that it returned back immediately along its parent artery, and passed above the carotid bifurcation. In this study , 22(45.83%) HRAs coursed anterior to the A1 segment , 20 (41.67%) coursed superior to the A1 segment , 4 (8.33%) coursed posterior to A1 segment , so most recurrent arteries coursed anterior to the A1 segment and were found on elevating the frontal lobe before visualizing the A1 segment frequently. The origin of HRA might adhere to the wall of anterior communicating aneurysms. The inverting adventitia of A1 could obscure the recurrent artery. Duringt operating on anterior communicating aneurysms, HRA might be damaged. HRA sometimes traveled a long path looping forward on the gyrus rectus. Removing the posterior 1 or 2 cm of the gyrus rectus to expose anterior communicating aneurysms might damage HRA. HRA supplied the anterior part of the caudate nucleus, anterior part of the outer segment of the globus pallidus, anterior third of the putamen, anteroinferior portion of the anterior limb of the internal capsule, and the uncinate fasciculus. The occlusion of HRA could cause hemiparesis with facial and brachial[10]. If the damage happened in the dominant hemisphere, it could also result in aphasia.

3.3 Perforating branches of A1 and A1 temporary occlusion

Perforating branches of A1 segment supplied blood to optic chiasm, middle portion of the anterior commissure, anterior limb of the internal capsule, para-olfactorial area, the splenium, and anterior part of the hypothalamus. Perlmutter reported perforators departing from proximal portion of A1 segement were more than from the distal portion of A1segement [11]. Yasargil reported that most perforating branches originated from the wall of proximal portion of A1 segment ,the originated point was at the 2～5 mm distal away from the bifurcation of internal carotid artery ,but not the bifurcation[2]. Mo WB reported 70% perforating branches came from A1 segment 5mm distal from the bifurcation of internal carotid artery , few came from proximal 3~5 mm of A1 segment[12]. In this study, 66 (65.35%) perforating branches originated from proximal 1/3 of A1 segment , 19 (18.81%) originated from middle 1/3 of A1 segment, and 16 (15.84%) originated from the distal1/3 of A1 segment. HRA adhered to the distal1/3 of A1 segment by arachnoid membrane trabeculaes frequently. middle 1/3 of A1 segmen t was the best position for temporary occlusion with a clip during the operation on anterior communicating aneurysms.

3.4 Perforating branches of AComA and clinical significance

The perforating branches coursed posttero-superiorly in the cistern of lamina terminalis. Xu T studied 99 perforating branches of AcoA in 45 brain specimens, the length of the branches was 9.46 ± 0.81 mm, the diameter was 0.29 ± 0.26 mm [13]. In this study , the length of 33 perforating branches was 9.31 ± 0.1.51 mm, the diameter was 0.43± 0.24 mm. There was statistically different in diameter compared the two studies (t- test,P<0.05), while length was no statistically different (t- test,P>0.05). Perlmutter reported AcoA perforating branches mainly supplied to the anterior hypothalamus, and some small branches supplied to the upper surface of optic chiasm[14]. If aneurysms arised from the anterior communicating artery, perforating branches of AComA might origin near aneurysms neck and adhere to the wall of the aneurysms. Dissecting and clipping the the aneurysms might damage the perforating branches. Water-electrolyte disorder, high fever and coma might occur after the branches were damaged .

3.5 Anterior communicating artery and cerebral angiography

It was difficult to defined AcomA and surrounding vessels on cerebral angiography because of short length and various forms of AcomA, polydirection of anterior communicating aneurysm and artery spasmodic ischemia. Another difficulty in angiographically defining the AcomA was that AcomA was not frequently oriented in a strictly transverse plane. The length of the AComA might oriente in an oblique or straight anterior-posterior plane if one ACA coursed between the hemispheres behind the other ACA. The boath sides ACAs were side by side as they passed between the cerebral hemispheres in 3 (20%) brain specimens, the left was anterior to the right in 7(46.67%) brain specimens, and the right was anterior to the left in 5 (33.33%) brain specimens for 15 brain specimens in this study. LING Feng considered, turning the head by 30° to the contralateral side was the best angle to examine AcomA during cerebral angiography[15].

In conclusion, anterior communicating artery complex was the primary sites of internal carotid aneurysm. Being familiar with the anatomy of this structure enabled neurosurgeons to treat the diseases in this area efficiently.

References

[1] Gonzalez LF, Pascual JM, Roda JM. Anatomic and hemodynamic study of anterior communicating artery complex [J]. Neurocirugi a (Astur), 2002, 13(4): 285-298

[2] Yasargil MG.Microneursurgery [M]. Stuttgart and New York, Georg Thieme Verlg, 1984, Vol.1, 131-151

[3] Gao SL, Lv YL, Zhang LW, et al. Practic Atlas of Brain Vessel [M]. Beijing:Science Press, 2008,51

[4] Stehbens WE. Aneurysms and anatomic variation of cerebral arteries [J]. Arch Pathol, 1963, 75:45-64

[5] Rhoton AL Jr. Aneurysms [J]. Neurosurgery. 2002 Oct;51 (4 Suppl): S121-58

[6] Brandt RA. Anatomic variations of the anterior cerebral and communicating arteries [J]. Neurobiologia, 1975, 38:31-40

[7] Huang Q, Fu WX, Liu HR, et al. An anatomic study of anterior communicating artery complex [J]. Chinese Journal of Neuromedicine, 2002 ,1(1):14-17

[8] Ru ML, Ren HJ, Gao JW, et al. Microsurgical anatomical study on A1 segment of anterior cerebral artery and its perforating arteries[J]. Journal of the Fourth Military Medical University, 2009, 30 (15): 1357-1359

[9] Mo WB, Du YQ, Jiang CW, et al. Microsurgical anatomy and clinical significance of Heubner's recurrent artery through pterional approach [J]. Acta Medicinae Sinica, 2002, 15(2):437-438

[10] Rhoton AL Jr. The supratentorial arteries[J]. Neurosurgery, 2002, 51: 53-120

[11] Perlmutter D, Rhoton AL Jr. Microsurgical anatomy of the anterior cerebral-anterior communicating-recurrent artery complex [J]. J Neurosurg,1976 45:259-272

[12] Mo WB, Du YQ, Jiang CG, et al. Microsurgical anatomy and clinical application of the anterior communicating artery complex through pterional approach [J]. Acta Medicinae Sinica, 2008, 21 (4): 650-652

[13] Xu T, Xue JY, Binod B, et al. Microsurgical anatomy of the anterior communicating artery complex in adult Chinese heads [J].Surgical Neurology, 2006, 65:155-161

[14] Perlmutter D, Rhoton AL Jr. Microsurgical anatomy of the anterior cerebral-anterior communicating-recurrent artery complex [J]. J Neurosurg, 1976, 45:259-272

[15] Ling F, Li T, Bao YH, et al. Imaging of Interventional Neuroradiology [M]. Beijing:People's Medicine Publing House, 1998:58

前交通动脉复合体的显微外科解剖研究

任伟东[1] 刘纯美[2] 迟焕芳[1△]

(1 青岛大学医学院解剖教研室 山东 青岛 266021;2 蒙阴县人民医院手术室 山东 蒙阴 276200)

摘要 目的：通过手术显微镜对前交通动脉复合体及穿支进行解剖和测量，进一步熟悉和掌握该复合体的结构及毗邻血管的走行，为前交通动脉瘤手术提供解剖学依据。方法：用红色乳胶经颈内动脉对 15 例(30 侧)福尔马林固定的湿性尸头进行灌注，然后在手术显微镜下对前交通动脉复合体进行解剖观测，所得结果用 SPSS17.0 软件进行统计分析。测量大脑前动脉 A1 和 A2 段、前交通动脉、Heubner 回返动脉、A1 段和前交通动脉穿支的长度、直径和各种形态变异。结果：未经选择的标本双侧 A1 发育无明显差异；术中对 Heubner 回返动脉、A1 段穿支、前交通动脉穿支应仔细分辨加以保护；A1 中 1/3 段穿支少，可作为前交通动脉瘤手术时临时阻断 A1 的部位；血管造影时前交通动脉不易看清与多种因素有关。结论：前交通动脉复合体复杂多变，熟悉前交通动脉复合体及穿支的解剖特点，对外科医生处理该区疾病至关重要。

关键词：前交通动脉复合体；前交通动脉；大脑前动脉；Heubner 回返动脉；显微解剖

中图分类号：R739.4，R322.8 文章标识码：A 文章编号：1673-6273(2011)02-233-04

作者简介：任伟东，(1975-)，男，硕士，主要从事临床应用解剖研究。手机：13475806769，E-mail : renweidongdong@126.com

△通讯作者：迟焕芳，E-mail : hfchi9200@163.com

(收稿日期：2010-10-03 接受日期：2010-10-30)