VIA MEDICA

ORIGINAL ARTICLE

Folia Morphol.
Vol. 69, No. 2, pp. 78–83

ISSN 0015–5659
www.fm.viamedica.pl

Radiological anatomy of the ambient cistern in children

T. Skadorwa[1, 2], M. Eibl[2], E. Zygańska[2], B. Ciszek[1, 2]

[1]*Department of Descriptive and Clinical Anatomy, Medical University of Warsaw, Poland*
[2]*Department of Paediatric Neurosurgery, Bogdanowicz Memorial Hospital for Children, Warsaw, Poland*

[Received 18 December 2009; Accepted 5 February 2010]

Ambient cistern (AC) is a thin extension of the subarachnoid space surrounding the brainstem at the level of the mesencephalon and pons. Despite various definitions, it constitutes an important landmark in clinical assessment of intracranial volume reserve. Although it is indisputably useful, there exists no defined standard for radiological examination for the dimensions and ranges in specific age groups. This paper aims to describe the ambient cistern anatomically and give the ranges of dimensions for proper radiological interpretation. The study was performed on 160 axial computed tomography (CT) examinations of Polish children of both sexes, aged 1–18 years, admitted to the hospital because of mild brain concussion. Pictures were made using a Siemens 8-row CT scanner, without contrast administration. We estimated distances at the level of the pons and midbrain, based on axial cross-sections, according to standard radiological protocol. The parameters included the width of the AC in its anterior and posterior part, the width of the tentorial notch, and the distance from the pons and sella. All measurements were analyzed statistically with StatSoft Statistica 8.0 software. The average width of the AC differs between age groups. It is greatest at 1–3 years (2.8 ± 0.6 mm) and lowest at 4–10 years (2.4 ± 0.6 mm). AC is more likely to be greater in its anterior part in boys. The distance from the sella to the pons is greatest in 1–3--year-old girls (6.9 ± 1.3 mm), and the tentorial notch is widest in the 15–18--year-old group (24.6 ± 2.4 mm). Dimensions of the AC correlate with intracranial reserve volume. This is particularly visible in the youngest children. Thin and narrow AC is not always a sign of raised intracranial pressure. It may be specific for the child's age. (Folia Morphol 2010; 69, 2: 78–83)

Key words: ambient cistern, radiological anatomy

INTRODUCTION

The ambient cistern (AC), as a part of the subarachnoid space, forms part of the complex cisternal system surrounding the mesencephalon and pons at the level above and below the tentorium cerebelli. This fact makes the AC a structure composed of two levels: supratentorial and subtentorial [4]. Each of these parts is related anatomically to different structures of the brainstem and may be the location of various pathologies. Its supratentorial part is related to the quadrigeminal plate posteriorly, and the cerebral peduncles anteromedially. In the subtentorial part it is bounded posteriorly by a ventral surface of pons and anteriorly by the dorsum sellae and clivus.

The ambient cistern, however, is defined by many authors in different ways. The classical description

Address for correspondence: T. Skadorwa, Department of Paediatric Neurosurgery, Bogdanowicz Memorial Hospital for Children, Niekłańska 4/24, 03–924 Warszawa, Poland, tel: +48 22 509 83 55, fax: +48 22 672 78 43, e-mail: tskadorwa@wum.edu.pl

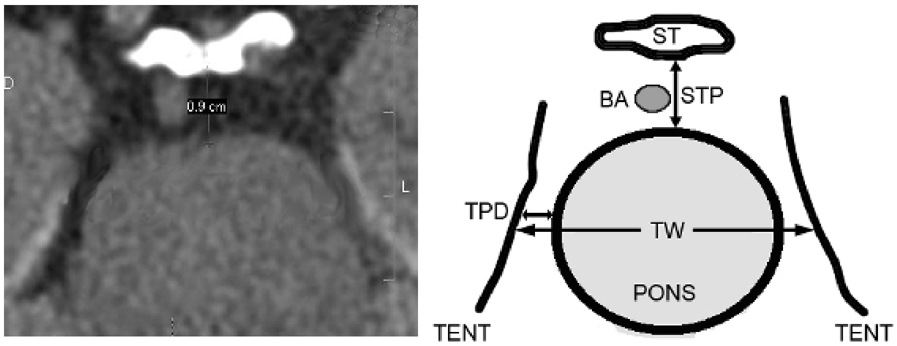

Figure 1. Dimensions of the subtentorial portion of the ambient cistern; STP — sella-to-pons dimension; TPD — tentorium-to-pons distance; TW — tentorial width; ST — sella turcica; BA — basilar artery; TENT — tentorial margin.

defines it as an extension of subarachnoid space surrounding the whole surface of the midbrain with adjacent interpeduncular fossa, cerebral crura, and lamina tecti [20]. Many authors, in turn, divide the space around the midbrain in four main components: interpeduncular cistern, crural cistern, ambient cistern, and quadrigeminal cistern [14, 16, 23]. According to this definition, the AC is bounded anteromedially by the cerebral peduncle, posteriorly by the temporal cortex, and connects posteromedially to the quadrigeminal cistern. At the subtentorial level, the AC occupies a superior part of the subarachnoid space surrounding the pons and connects to the pontine cistern anteroinferiorly.

Despite this classificational incoherence, the existence of the AC is clinically important because of its correlation with assessment of intracranial volume reserve. Thin and narrow subarachnoid cisterns are a common radiological sign of increased intracranial pressure [1]. Asymmetrical lack of AC reflects a shift of the temporal lobe into the tentorial notch and compression of the midbrain by temporal lobe herniation. Therefore, a proper interpretation of AC shape and dimensions is essential. However, there exists no defined reference to which the observed AC might be compared in children. The literature is poor in its descriptions of this region in adults, and there is not a single article on the anatomy of the AC in paediatric patients.

In this paper we aim to give a preliminary description of the radiological anatomy of the AC and create a reference for AC dimensions, according to age groups and level of observation.

MATERIAL AND METHODS

The AC description was performed by the use of anonymised 1.5 mm axial computed tomography (CT) scans of the whole head of 160 Polish children of both sexes (80 male, 80 female), between 1 and 18 years of age. The images were divided into 4 age groups, each containing 40 cases (1–3 years, 4–10 years, 11–14 years, and 15–18 years). The indications to CT examination included mild brain concussion due to superficial head trauma followed by an episode of transient unconsciousness and vomiting due to meningeal irritation, or without these symptoms. Patients with any intracranial pathology were excluded from the study. Pictures were acquired with a Siemens 8-row CT scanner, without contrast administration. Pictures were recorded in DICOM standard mode and then examined using a Siemens Magic Web Browser equipped with measurements tools.

The AC dimensions were measured at two levels: 1) at the level of the dorsum sellae, and 2) at the level of the inferior colliculi.

The first group of measurements comprised the distance between the dorsum sellae and ventral surface of the pons (STP, sella-to-pons dimension), the distance from the tentorial margin to the pons bilaterally (TPD), and the width of the tentorial notch in the middle of the sagittal dimension the pons (TW) (Fig. 1).

The second group included, bilaterally, the width of the AC in its anterior part, at the level of the posterior margin of the cerebral peduncle shape (AAC), and in the posterior part of the AC, at the level of the cerebral aqueduct (PAC). We also measured the longitudinal dimension of the AC from the anterior-most point of the AC to the posterior-most point of the midbrain colliculi (ACL). The last dimension at this level was the width of the tentorial notch at the level of the cerebral aqueduct (TNW) (Fig. 2).

We measured also two general dimensions of the skull: longitudinal (LONG) and transverse (TR), at the level of the bottom of the third ventricle.

All patient examinations were performed at the same level and values analyzed statistically (t-Student test) with StatSoft Statistica 8.0 software.

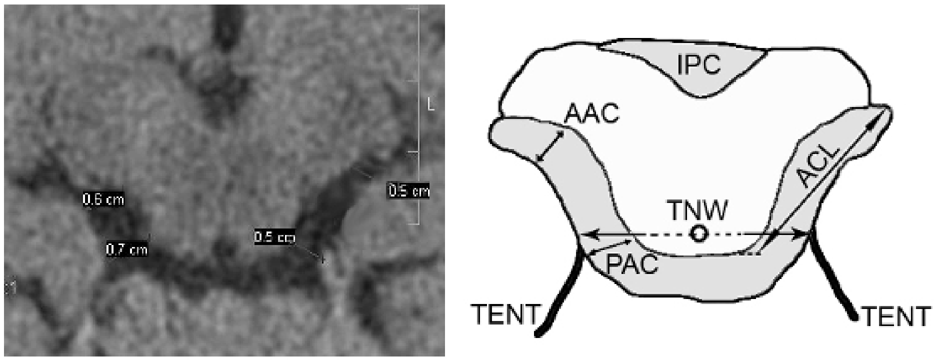

Figure 2. Dimensions of the supratentorial portion of the ambient cistern (AC); AAC — width of the anterior part of the AC; PAC — width of posterior part of the AC; TNW — tentorial notch width; ACL — length of AC; IPC — interpeduncular cistern; TENT — tentorial margin.

RESULTS

Detailed analysis of the scans showed the radiological features of the AC, estimated according to the definition given by Ulm et al. [23]. It occupied a region around the mesencephalon, bilaterally, from the level of the cerebral crura anteriorly to the quadrigeminal plate and to the tentorium posteriorly. The level of the tentorium constituted the intracisternal boundary between the so-called supratentorial and subtentorial portions. The anatomical relations and clinical significance of these two parts differ so much that we introduced distinct parameters to measure them.

Radiologically, the anterior-most point of the AC was situated lateral to the lateral-most point of the cerebral crus, and was found above the tentorium. The anterior portion of the AC was anterolaterally bounded by the uncus and temporal cortex, and medially by the cerebral crus. Posteriorly it was connected to the posterior portion of the AC at the level of the posterior-most point of the cerebral crus. From this point to the level of the cerebral aqueduct, we recognized the posterior portion of the AC, which could also better be observed supratentorially. It was anatomically related to the tentorium cerebelli and temporal cortex located posterolaterally, and the posterior surface of the lamina tecti with geniculate bodies located anteromedially. The posterior portion of the AC extended medially to the quadrigeminal cistern which, according to previous studies, was defined as the space directly posterior to the quadrigeminal plate in the transverse plane [14, 23]. Therefore, the longitudinal axis of the AC, distinguished supratentorially, was oblique in the transverse plane and directed anterolaterally from the rear to the front portion of the cistern. This distance (ACL) was 11.5 ± 1.8 mm in boys and 11.3 ± ± 1.5 mm in girls ($p < 0.05$).

Measurements taken at the tentorium level showed differences between sex groups: the average STP (Table 1) was greater in girls than in boys (6.7 ± 1.7 mm and 6.4 ± 1.7 mm, respectively; $p < < 0.05$). This interval measured less than 6 mm only in the youngest boys (5.8 ± 1.3 mm). The mean AC width at this level, estimated by TPD (4.0 ± 1.8 and 3.8 ± 1.6 mm in boys and girls, respectively), was greatest in the youngest group (4.5 ± 1.9 mm, $p < < 0.05$) and gradually decreased to reach a value 3.2 ± 1.5 mm in 15–18-year-old adolescents. Average

Table 1. Values of measured parameters regarding sex and age groups: subtentorial portion of ambient cistern (AC)

		1–3	4–10	11–14	15–18
STP [mm]	Male	5.8 ± 1.3	6.8 ± 2.3	6.4 ± 1.4	6.4 ± 1.7
	Female	6.9 ± 1.3	6.6 ± 2.2	7.0 ± 1.8	6.3 ± 1.4
TPD [mm]	Male	4.5 ± 2.0	4.2 ± 1.8	4.00 ± 1.5	3.2 ± 1.5
	Female	4.5 ± 1.7	4.0 ± 1.7	3.5 ± 1.5	3.3 ± 1.5
TW [mm]	Male	35.1 ± 5.5	39.2 ± 3.1	40.1 ± 4.7	39.5 ± 5.5
	Female	33.6 ± 5.1	36.1 ± 5.1	37.2 ± 4.2	37.4 ± 4.7

STP — sella-to-pons dimension; TPD — tentorium-to-pons distance; TW — tentorial width

Table 2. Values of measured parameters regarding sex and age groups: supratentorial portion of ambient cistern (AC)

		1–3	4–10	11–14	15–18
AAC [mm]	Male	3.0 ± 0.9	2.7 ± 0.7	2.9 ± 0.8	2.7 ± 0.8
	Female	3.0 ± 0.7	2.6 ± 0.7	2.9 ± 1.0	2.6 ± 0.9
PAC [mm]	Male	2.6 ± 0.6	2.2 ± 0.9	2.4 ± 0.7	2.8 ± 0.8
	Female	2.6 ± 0.8	2.3 ± 0.7	2.6 ± 0.9	2.4 ± 0.8
TNW [mm]	Male	22.0 ± 2.4	23.4 ± 3.1	24.8 ± 3.3	25.3 ± 2.3
	Female	21.4 ± 1.8	22.4 ± 3.3	23.7 ± 2.4	23.8 ± 2.4
ACL [mm]	Male	9.4 ± 1.8	11.6 ± 1.1	11.7 ± 1.9	12.0 ± 2.0
	Female	10.7 ± 1.0	10.4 ± 0.8	12.0 ± 2.1	11.6 ± 1.1

AAC — width of anterior part of AC; PAC — width of posterior part of AC; TNW — tentorial notch width; ACL — length of AC

Table 3. Values of general skull parameters measured

		1–3	4–10	11–14	15–18
LONG [mm]	Male	165.9 ± 10.0	172.1 ± 7.9	177.8 ± 6.8	183.4 ± 6.7
	Female	159.4 ± 6.3	171.1 ± 8.1	170.8 ± 7.9	177.8 ± 7.9
TR [mm]	Male	131.8 ± 6.1	142.3 ± 5.1	146.4 ± 6.8	146.7 ± 4.9
	Female	129.9 ± 6.0	137.5 ± 5.8	142.4 ± 5.1	143.4 ± 5.2

LONG — longitudinal dimension of the skull; TR — transverse dimension of the skull

TW in this age group, however, was the largest only in girls and ranged in all cases from 25.0 to 50.1 mm (median value 37.2 mm).

The supratentorial portion width of the AC was narrower than at the level of the dorsum sellae in all cases ($p < 0.05$), being 2.7 ± 0.2 and 2.6 ± ± 0.2 mm, respectively, in boys and girls, with a maximal average width in 1–3-year-old children (2.8 ± ± 0.1 mm) (Table 2). The youngest children presented the greatest dimensions in the anterior portion of the AC (3.0 ± 0.8 mm), while the posterior portion was maximal and comparable in 1–3 and 15–18 age groups (2.6 ± 0.7 and 2.6 ± 0.8 mm, respectively). Minimal values of average AC width were observed in children 4–10 years old (2.4 ± 0.1 mm). TNW was greater in girls (28.9 ± 2.7 mm) than in boys (23.9 ± 3 0 mm) and greatest in 15–18-year-old adolescents among the age groups (24.6 ± 2.4 mm *vs* 21.7 ± 2.1 mm in the youngest children).

General skull dimensions provided data for comparison purposes (Table 3). The greatest LONG and TR were observed in 15–18-year-old children (LONG = 180.8 ± 7.7; TR = 145.1 ± 5.3 mm). Children aged 1–3 years presented lesser values of these parameters (LONG = 162.7 ± 8.8; TR = 130.9 ± 6.1 mm).

Statistical analysis showed negative correlation between age and subtentorial AC width ($r = -0.31$, $p < 0.05$), but we observed a coincidence of increasing AC width with TNW development ($r = 0.25$, $p < 0.05$). The increment of AC width also presented a positive correlation to transverse dimensions of the skull ($r = 0.06$, $p < 0.05$).

DISCUSSION

Methodology discussion

Previous studies on the AC emphasize its clinical impact: being a part of the perimesencephalic cisternal complex it constitutes an important anatomical landmark for assessment of cerebrospinal fluid reserve spaces, holds vital neurovascular structures [9, 14–16, 19, 23, 24], and commonly serves as a favourable surgical approach to perimesencephalic lesions [7, 9, 15, 17, 19, 23, 24]. It is also widely useful in radiological examinations, being able to show the reasons for acute ischaemia in posterior cranial fossa structures (i.e. the hyperdense posterior cerebral artety sign, where hyperdense posterior cerebral artery marks the incidence of acute ischaemia in posterior cerebral artety territory) [5, 10, 18].

In many of these cases, CT examination seems to be primarily performed, as in most traumatic brain injuries. AC dimensions and shape play a crucial role in determining qualification to surgical treatment [5]. CT scans, however, provide only orientational insight into AC surroundings and details, compared to more exact neuroimaging methods. Being the first and often only radiological evaluation [1, 2, 6], it seems necessary to describe this region based on CT scans, in a morphometric fashion.

Paediatric neurosurgical patients often suffer from symptoms that result from age-specific mechanisms of head injury. Based on typical groups of patients and the paediatric care system in Poland, we distinguished four age groups that seem to correspond with characteristic neurosurgical problems bringing the patients to the hospital: babies, infants, children, and adolescents. Such age groups are the most clinically similar from a surgical point of view and they present approximate anatomical conditions.

Discussion of results

AC pathologies are rarely reported in literature. There exist, however, a few descriptions on AC arachnoid cysts and tumours that prove the clinical importance of this region [3, 12]. Moreover, many other studies have focused on microsurgical and endoscopic examination [1, 11, 13, 14, 16, 21–23], yet none of them has given precise directions about the AC limitations and dimensions. Wang et al. reported the general appearance of the AC region based on operating microscope findings. They also gave a description of the contents of this area and focused on a surgical approach to them [24]. Okuchi et al. [18] presented an magnetic resonance imaging (MRI)-based study on AC surroundings concluding that MRI scans can be used to determine the real location of lesions close to the AC. Chakeres et al. [5] combined CT scans and angiography in order to show pathologies within the AC. Matsuno et al. [14] described membranes separating the AC from the connecting subarachnoid cisterns of the posterior cranial fossa. In our opinion, international literature lacks a detailed description of the AC focused on its developmental features, which might be useful for paediatric radiologists. We think that the description given solves the problem of AC references and refreshes the insight into this important area.

According to Chakeres and Kapila [4], we distinguished supratentorial and subtentorial portions of the AC. We did not focus on the tentorial edge, described by these authors, because of the impossibility to assess this portion in our material. The measurements we made showed that the subtentorial portion of the AC is wider than the supratentorial and decreases with age. This part is larger in babies in both transverse and sagittal axes, compared to children older than 11 years. Girls have a slight tendency for these dimensions to be longer, which is not observed as far as the tentorial width at the level of the dorsum sellae is concerned. In all age groups this element was 33–40 mm wide, which promotes the youngest group to present relatively large spaces between the pons and tentorial margin in radiological evaluation. The increase of 6 mm, on average, of the tentorial width is accompanied with the loss of 1 mm of peripontine space, which may be explained by the uneven increment of the pons and mesencephalon.

The supratentorial portion, in turn, tends to be more constant for tentorial conditions and less related to transverse axis dimensions. Its longitudinal axis increases with skull growth, and we observed a coincidence between the increase of AC width and the width of the tentorial notch. Boys revealed generally slightly wider anterior portions of supratentorial AC compared to girls, which presented more spacious its posterior part. It is worth noting that the tentorial notch width was larger in boys than in girls, which may suggest different mesencephalic shape development. The increase in tentorial notch width is 2.5 and 3.5 mm, respectively, for girls and boys from 1 to 18 years of age, which influences the quadrigeminal cistern more than the anteromedially located AC. 1–3-year-old boys reveal the highest values of AC width. The narrowest AC is found in 4–10-year-old girls. This group also shows the least anterior portions, which in turn is largest in boys of 1–3 years of age. The posterior part, however, is the largest in 15–18-year-old male adolescents and the smallest in 4–10-year-old boys. These slight differences in developmental patterns between the sexes have, in our opinion, no clinical importance and may result from methodological errors. Nevertheless, they present radiologically important tendencies that may be useful for paediatric examinations and surgical planning purposes.

CONCLUSIONS

Based on the study we conclude that:

1. The AC should be defined by cerebral peduncles and differentiated from the crural and quadrigeminal cistern.
2. The subtentorial portion of the AC is wider than the supratentorial portion. The subtentorial part tends to decrease with children's age, while supratentorial part is more constant in size.

3. The AC is the widest in 1–3-year-old boys and the narrowest in 4–10-year-old girls.
4. The increment of width of the tentorial notch correlates with that of the AC.
5. CT scans equipped with measuring tools are sufficient for AC assessment.

REFERENCES

1. Barr RM, Gean AD, Le TH (2007) Craniofacial trauma. In: Brant WE, Helms CA eds. Fundamentals of diagnostic radiology. Lippincott, Williams & Wilkins, Philadelphia, pp. 55.
2. Besenski N (2002) Traumatic injuries: imaging of head injuries. Eur Radiol, 12: 1237–1252.
3. Bromowicz J, Wicentowicz Z, Lechwacka-Krawczyk M, Jedlińska M, Maciejak A (1976) Cyst of cisterna ambiens: case report. Neurol Neurochir Pol, 10: 805–807.
4. Chakeres DW, Kapila A (1985) Radiology of the ambient cistern. Part I: Normal. Neuroradiology, 27: 383–389.
5. Chakeres DW, Kapila A, LaMasters D (1986) Radiology of the ambient cistern. Part II: Pathology. Neuroradiology, 28: 4–10.
6. Gallagher CN, Hutchinson PJ, Pickard JD (2007) Neuroimaging in trauma. Curr Opin Neurol, 20: 403–409.
7. Hayashi N, Hamada H, Umemura K, Kurosaki K, Kurimoto M, Endo S (2005) Selection of surgical approach for quadrigeminal cistern arachnoid cyst. No Shinkei Geka, 33: 457–465.
8. Hirano A, Matsumura S, Maeda Y, Hashimoto Y, Hirai H (1995) Two cases of isolated ambient cistern hematoma after head injury. No To Shinkei, 47: 281–284.
9. Ikeda K, Shoin K, Mohri M, Kijima T, Someya S, Yamashita J (2002) Surgical indications and microsurgical anatomy of the transchoroidal fissure approach for lesions in and around the ambient cistern. Neurosurgery, 50: 1114–1119.
10. Krings T, Noelchen D, Mull M, Willmes K, Meister IG, Reinacher P, Toepper R (2006). The hyperdense posterior cerebral artery sign: a computed tomography marker of acute ischemia in the posterior cerebral artery territory. Stroke, 37: 399–403.
11. Lü J, Zhu X (2005) Microsurgical anatomy of the interpeduncular cistern and related arachnoid membranes. J Neurosurg, 103: 337–341.
12. Maiuri F, Corriero G, Gallicchio B, Simonetti L (1987) Lipoma of the ambient cistern causing obstructive hydrocephalus. J Neurosurg Sci, 31: 53–58.
13. Marinković S, Gibo H (1994) The neurovascular relationships and the blood supply of the oculomotor nerve: the microsurgical anatomy of its cisternal segment. Surg Neurol, 42: 505–516.
14. Matsuno H, Rhoton AL Jr, Peace D (1998) Microsurgical anatomy of the posterior fossa cisterns. Neurosurgery, 23: 58–80.
15. Milisavljević M, Marinković S, Marinković Z, Malobabić S (1998) Anatomic basis for surgical approach to the distal segment of the posterior cerebral artery. Surg Radiol Anat, 10: 259–266.
16. Nagata S, Rhoton AL Jr, Barry M (1988) Microsurgical anatomy of the choroidal fissure. Surg Neurol, 30: 3–59.
17. Nagata S, Sasaki T (2005) The transsylvian trans-limen insular approach to the crural, ambient and interpeduncular cisterns. Acta Neurochir (Wien), 147: 863–869.
18. Okuchi K, Fujioka M, Konobu T, Fujikawa A, Nishimura A, Miyamoto S, Nakagawa H, Iwasaki S (1993) Traumatic primary brain stem injury and ambient cistern hematoma evaluated with magnetic resonance imaging. No Shinkei Geka, 21: 799–804.
19. Siwanuwatn R, Deshmukh P, Zabramski JM, Preul MC, Spetzler RF (2005) Microsurgical anatomy and quantitative analysis of the transtemporal-transchoroidal fissure approach to the ambient cistern. Neurosurgery, 57 (suppl. 4): 228–235.
20. Standring S (2008) Ventricular system and subarachnoid space. In: Standring S ed. Gray's anatomy. 40th Ed. The anatomical basis of clinical practice. Churchill Livingstone, Oxford, pp. 242–243.
21. Sufianov AA, Sufianova GZ, Iakimov IA (2009) Microsurgical study of the interpeduncular cistern and its communication with adjoining cisterns. Childs Nerv Syst, 25: 301–308.
22. Sufianov AA, Zaitsev AP, Iakimov IuA, Manzharo OB, Sufianova GZ (2007) The topographic anatomy of the interpeduncular cistern and endoscopic ventriculocisternostomy in the region of the bottom of the third ventricle. Zh Vopr Neirokhir Im N N Burdenko, 1: 40–44.
23. Ulm AJ, Tanriover N, Kawashima M, Campero A, Bova FJ, Rhoton A Jr (2004) Microsurgical approaches to the perimesencephalic cisterns and related segments of the posterior cerebral artery: comparison using a novel application of image guidance. Neurosurgery, 54: 1313–1327.
24. Wang F, Sun T, Li XG, Li ZZ (2007) Microsurgical anatomy and surgical approach of the ambient cistern. Zhonghua Yi Xue Za Zhi, 87: 165–169.