A review of SPECT studies in psychiatry in China

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Background: Studies of mental disorders using single photon emission computed tomography (SPECT) have been done for many years in China. Many results have been obtained. We review these findings and introduce them to the outside world.

Methods: SPECT papers available on the Chinese Biomedical Bibliographic Database, focusing on depression, schizophrenia, Alzheimer's disease (AD), vascular dementia (VD), anxiety disorder, and obsessive compulsive disorder (OCD) in China, were reviewed and the results were compared with those obtained outside China.

Results: We found that regional cerebral blood flow (rCBF) was abnormal in mental disorders, but the specificity of the abnormality is not yet consistent. Lower perfusion of rCBF could be seen in frontal, temporal, and parietal lobes of patients with depression, AD, schizophrenia, and VD. It seems that abnormality of the frontal lobe is more common in depression and schizophrenia, but temporal lobe abnormalities are more common in AD and VD. The perfusion of rCBF in the parietal lobe seems to be related to aging. Abnormalities in the occipital lobe and basal ganglia seem to be more associated with vascular problems. Thalamic dysfunction was mainly correlated with VD, and that of the cingulate largely with depression and schizophrenia. Hippocampal abnormalities were associated with AD. There were few reports on changes in anxiety disorders and other mental problems.

Conclusion: There is no specific biological marker of SPECT for individual mental disorders. Further study is needed to provide more specific information on the pathophysiology of mental disorders. It seems that brain abnormalities are similar in Chinese and non Chinese psychiatric patients.

Keywords: depression, Alzheimer's disease, vascular dementia, schizophrenia, anxiety disorder, obsessive compulsive disorder, SPECT

Introduction

Functional brain imaging has assumed a leading role in neuropsychiatric research. However, findings reported for mental disorders often vary. Whether this reflects diversity in pathophysiology or heterogeneity of imaging techniques and data analysis procedures is still unknown. Single photon emission computed tomography (SPECT) is one of the techniques of functional imaging that can be used to detect regional cerebral blood flow (rCBF) in the brain of subjects in different states. rCBF is closely related to metabolism and physiology of the brain. The technique of SPECT was first used in psychiatry in the early 1990s (Austin et al 1992), when it was found that depressed patients showed reduced uptake in most cortical and subcortical regions examined, most significantly in temporal, inferior frontal, and parietal areas. SPECT was first used in the study of depression in China in 1995 (Deng et al 1995), then later in schizophrenia, Alzheimer's disease, and other mental disorders. Since then, many studies have been made using SPECT in mental disorders in China. What are the results of SPECT studies in China? What are the differences between these results in China and those in other countries? Here we review SPECT studies in psychiatry in China.

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Method

We collected all SPECT papers focused on depression, schizophrenia, Alzheimer's disease, anxiety disorder, and obsessive compulsive disorder published in the Chinese language in China and available in the Chinese Biomedical Bibliographic Database from 1990 to 2004. All publications have been copyrighted and published openly in China. All patients and researchers are Chinese. All overlapping articles were excluded.

Results

We found a total of 31 articles fitting our defined criteria. Three were excluded due to overlap. Six papers were studies on depression (Deng et al 1995, 1997; Zhao et al 1998, 2000; Jiang et al 2000; Ang et al 2003), 9 studied Alzheimer's disease (AD) (Jia and Gao 1996; Liu et al 1997; Ang, Jiang, et al 1998; Ang, Zhang, et al 1998; Ang et al 1999, 2000; Xu, Huang, et al 1999; Xu, Zheng, et al 1999; Peng et al 2001), and 13 others studied schizophrenia (Hu et al 1996; Li, Deng, et al 1996; Li, Tang, et al 1996; Li, Zhao, et al 1996; Li et al 1997; Yu et al 1998; Li et al 2001; Zhou et al 2001; Li, Jiang, 2002; Li, Xiu, et al 2002; Liu et al 2002; Wan et al 2002; Wang et al 2003). Only 1 study was found on anxiety disorder (Wan et al 2002), 1 on obsessive compulsive disorder (OCD) (Li, Jiang, et al 2002), and 1 on heroin addicts (Wang et al 2003).

Table 1 A review of SPECT papers on depression in China

Authors	Number and age	Course and method	Diagnostic criteria and tools	rCBF results of patients
Deng et al (1995)	5 P (23–60 yr, 40 ± 12)	< 2 yr first episode Self-control ^{99m}Tc-ECD 1110 MBq	CCMD-2 HAMD (24 items) 22–43	Low in right temporal, frontal, parietal, and left occipital lobes; bilateral basal ganglia in 3 patients with endogenous depression. Low in right temporal lobe in reactive depression.
Deng et al (1997)	11 P (23–60 yr, 43 ± 12) 13 C (20–59 yr, 42 ± 14)	7 ± 3 m Drug free or stop for 1 wk to 12 m ^{99m}Tc-ECD 925–1225 MBq ROI	CCMD-2 HAMD (24 items) 38.9 ± 10.8	Low in left inferior frontal, left anterior temporal, and cingulate. Low in right superior, inferior frontal and bilateral parietal, and occipital lobes. Asymmetry in right superior frontal.
Zhao et al (1998)	27 P (17–51 yr, 33 ± 11) 15 C (20–53 yr, 36 ± 12)	3 m–2 yr first episode drug free ^{99m}Tc-ECD 1110 MBq ROI	ICD-10 WCST HAMD (24 items) 31–38	Low in left frontal, temporal lobes in baseline and activated. Low in left parietal lobe only in activated.
Zhao et al (2000)	39 P (17–55 yr) 17 C (21–50 yr) 18ED (62–76 yr) 21C (60–72 yr)	3 m–2 yr first episode drug free ^{99m}Tc-ECD ROI	ICD-10 CCMD-2-R WCST HAMD (24items) 24–49	Low in bilateral frontal and temporal lobes both at baseline and activated, but low in parietal lobe only at activated in non-old patients. Low in bilateral frontal, temporal lobes, and right basal ganglia both at baseline and activated in old patients with depression, but right parietal only at activated.
Jiang et al (2000)	22 ED (67 ± 4yr) 26 C (68 ± 4yr)	No course, first episode ^{99m}Tc-ECD 925–1110 MBq ROI RAR	ICD-10 HAMD (24 items) MMSE	RAR: Low in bilateral basal ganglia, frontal, and occipital lobes; right parietal lobe and thalamus. Cognitive disorder related to bilateral occipital, left temporal lobe.
Ang et al (2003)	22 ED (67 ± 4 yr) 26 C (68 ± 4 yr) 26 AD (68 ± 7 yr)	No course, first episode of ED Drug free ROI RAR	DSM-IV HAMD (24-items) MMSE	Low in right parietal, bilateral frontal and occipital lobes. Perfusion asymmetry in temporal, frontal and occipital lobes lower in left than right but thalamus lower in right than left. Increase in bilateral temporal lobe, basal ganglia, thalamus, and cingulate in patients with depression compared with AD patients.

Abbreviations: AD, Alzheimer's disease; C, controls; CCMD-2, Chinese Classification of Mental Disorders-2; DSM-IV, Diagnostic and statistical manual of mental disorders, 4th edition; ED, elderly depression; HAMD, Hamilton depression scale; ICD-10, The ICD-10 classification of mental and behavioural disorders, clinical description and diagnostic guideline; MMSE, mini-mental state examination; m, month; P, patients; RAR, radioactive ratios; ROI, regions of interest; wk, week; WCST, Wisconsin card sorting test; yr, years.

Depression

As shown in Table 1, there was only 1 retrospective study, which included just 5 patients (Deng et al 1995). Patients with reactive depression showed low rCBF only in the right temporal lobe whereas subjects with endogenous depression displayed low rCBF both in the right temporal lobe and the right frontal-parietal lobe. Five other papers concerned prospective controlled studies with larger samples, from 11 to 39 subjects, using ICD-10, DSM-IV, CCMD-2, and CCMD-2-R criteria.

All 6 studies found lower rCBF in the frontal lobe of patients with depression than in controls: 1 was in the right frontal (Deng et al 1995), 2 in the left frontal (Deng et al 1997; Zhao et al 1998), and 3 were bilateral (Jiang et al 2000; Zhao et al 2000; Ang et al 2003). Four authors found lower rCBF in the temporal lobe also (Deng et al 1995, 1997; Zhao et al 1998, 2000). Five studies found lower rCBF in the parietal lobe, mainly in the right (Deng et al 1995, 1997; Jiang et al 2000; Zhao et al 2000; Ang et al 2003). Four studies showed lower rCBF in the occipital lobe, 1 in the left (Deng et al 1995), the other in the right (Deng et al 1997), and 2 in both sides in older-age depression (Jiang et al 2000; Ang et al 2003). Three studies also reported lower rCBF in basal ganglia, 2 on both sides (Deng et al 1995; Jiang et al 2000), but 1 only in the right side of old patients (Zhao et al 2000). Three studies dealt with old patients with depression; the results showed lower rCBF in the right parietal lobe (Zhao et al 2000; Ang et al 2003), and only 1 study showed lower rCBF in the left parietal in the activated state (Zhao et al 1998). Patients in the studies of Jiang et al (2000) and Ang et al (2002) were the same. Only Deng (1997) reported lower rCBF in cingulate, and only Jiang et al (2000) in the thalamus. Perfusion asymmetry in temporal, frontal, and occipital lobes was observed in 2 studies, with lower perfusion in the left than in the right. Also perfusion in the thalamus was lower in the right than in the left (Deng et al 1997; Ang et al 2003). Three studies used patients with first-episode depression (Zhao et al 1998; Jiang et al 2000; Ang et al 2003).

Table 2 A review of SPECT studies on Alzheimer's disease in China

Authors	Number and age	Course and method	Diagnostic criteria and tools	rCBF results of patients
Jia et al (1996)	AD 9 (53–81 yr, 64 ± ??) VD 10 (52–70 yr, 59 ± ??)	No course ^{99m}Tc-ECD	ICD-10 NINCDS-ADRDA VD Hachinski scale > 7 AD Hachinski scale < 4 CT scan WAIS	Low in frontal-parietal lobe 3 cases, in temporal-parietal lobe, parietal lobe, and frontal-temporal lobe each 1 case in AD. Results of patients with VD same with CT results; no detailed description.
Liu et al (1997)	VD 33 (50–70 yr, 61 ± 6) AD 21 (52–76 yr, 60 ± 7) C 24 (51–68 yr, 59 ± 6)	0.5–3 yr VD 1.6 ± 0.6 AD 3.1 ± 0.6 ^{99m}Tc-ECD 740–825 MBq self-statistic method for radio-number	DSM-III-R VD Hachinski scale > 7 AD Hachinski scale < 4 WAIS WMS HRNB	Low in left frontal and temporal lobe related to VIQ in VD, but low in left temporal and right frontal lobe with VIQ in AD. Low in left frontal, and right parietal, thalamus related to FIQ in VD, but low in right parietal and occipital with PIQ in AD.
Ang, Zhang, et al (1998)	AD 36 (71 ± 6 yr) VD 35 (72 ± 4 yr) C 37 (70 ± 4 yr)	No course ^{99m}Tc-ECD 925–1110 MBq ROI	DSM-IV CT scan VD Hachinski scale > 7	Compared with control subjects, low in all lobes except bilateral occipital in AD. Compared with control subjects, low in all parts except right occipital and bilateral frontal in VD. Comparing VD, low in bilateral frontal and right parietal lobe in AD.
Ang, Jiang, et al (1998)	AD 17 (51–80 yr, 70 ± 8) VD 12 (67–82 yr, 73 ± 5)	No course ^{99m}Tc-ECD 925–1110 MBq ROI RAR	DSM-IV VD Hachinski scale > 7 AD Hachinski scale < 4 MMSE CT or MRI scan	Abnormal rate (%) of AD was 38.2 in frontal, 47.1 in temporal, 52.9 in parietal, and 5.9 in occipital lobes. Lower in left superior and inferior temporal lobe than in right within AD group. Abnormal rate (%) of VD was 50.0 in frontal, 58.3 in temporal, 33.3 in parietal, and 16.7 in occipital lobes, 12.5 in basal ganglia and 8.3 in thalamus. Lower in left superior and inferior temporal, left parietal, and left occipital lobes than in right lobes within VD group. Lower in right inferior temporal and right occipital in AD than in VD, but higher in left parietal in AD than in VD.

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Table 2 *continued*

Authors	Number and age	Course and method	Diagnostic criteria and tools	rCBF results of patients
Xu, Huang, et al (1999)	VD 30 (62–89 yr, 75 ± 6) PD 31 (61–90 yr, 74 ± 6) C 30 (60–78 yr, 71 ± 4)	VD 2.5 yr PD 3yr ^{99m}Tc-ECD 925–1110 MBq RAR	DSM-III-R NINDS-AIREN VD Hachinski scale > 7 MMSE CT scan NPT	Lower in all lobes except frontal lobe, right occipital and left thalamus in VD than in control. Lower in parietal, temporal, basal ganglia and thalamus in PD than in control. Lower in left temporal lobe than that of right in PD. No difference between VD and PD.
Ang et al (1999)	AD 36 (71 ± 6 yr) VD 35 (72 ± 4 yr) C 37 (70 ± 4 yr)	No course ^{99m}Tc-ECD 925–1110 MBq ROI RAR	DSM-IV CT scan VD Hachinski scale > 7 MMSE NPT	Results of RAR: Lower in all lobes except bilateral occipital lobe in AD than in control. Lower in all lobes except right occipital and bilateral frontal lobes in VD than in control. Lower in right parietal and bilateral frontal in AD than in VD.
Xu, Zheng, et al (1999)	AD 15 (59–79yr, 69±6) VD 24 (43–83yr, 70±9) C 15 (50–85yr, 66±9)	No course ^{99m}Tc-ECD Patlak plot analysis	DSM-III-R NINCDS-ADRDA MMSE Hachinski scale	Lower in AD and VD than in control. Lower in frontal, temporal, and parietal lobe in AD group than in control. Lower in all lobes and basal ganglia in VD group than that of control. Low in temporal and parietal related to MMSE in AD. No report compared AD and VD.
Peng et al (2001)	AD 36 (60–84 yr, 71 ± 8) VD 32 (60–81 yr, 70 ± 8) C 30 (60–83 yr, 70 ± 8)	7–29 m (16 ± 8) 3–30 m (17 ± 8) ^{99m}Tc-ECD 925–1110 MBq RAR	DSM-III-R NINCDS-ADRDA MMSE Hachinski scale MRI	Lower in AD and VD than in control. Lower in temporal, frontal, parietal and hippocampus in AD than in control. Lower in temporal, parietal, frontal, thalamus and basal ganglia in VD than in control. The severity of AD was related to lower rCBF in hippocampus.
Ang et al (2002)	AD 66 (60–65, 9 66–70, 14 > 70, 43) C 73 (60–65, 25 66–70, 23 > 70, 25)	No course RAR	DSM-IV MMSE MRI	Lower in bilateral temporal, frontal, and parietal lobes in AD than in control. No difference between 60–65, 66–70, > 70 years-old groups.

Abbreviations: AD, Alzheimer's disease; C, control, CT, computer tomography; DSM-IV, DSM-III, Diagnostic and statistical manual of mental disorders, 4th edition, 3rd edition; FIQ, final IQ; Hachinski, Hachinski ischemic score; HRNB, Halstead-Reitan neuropsychological battery; ICD-10, The ICD-10 classification of mental and behavioural disorders, clinical description and diagnostic guideline; m, month; MMSE, mini-mental state examination; MRI, magnetic resonance imaging; NINCDS-ADRDA, National Institute of Neurological and Communicative Disorders and Stroke-Alzheimer's Disease and Related Disorders Association; NINDS-AIREN, National Institute of Neurological Disorders and Stroke-Association Internationale pour la Recherche et l'Enseignement en Neurosciences ; PD, Parkinson's disease, PIQ, practice IQ; RAR, radioactive ratios; ROI, regions of interest; VD, vascular dementia; VIQ, verbal IQ, WAIS, Wechsler's adult intelligence scale; WMS, Wechsler's memory scale; NPT, neuropsychological test; yr, year;

Alzheimer's disease

We found that all of the 8 papers dealing with AD reported lower rCBF in frontal, temporal, and parietal lobes (Table 2) (Jia and Gao 1996; Liu et al 1997; Ang, Jiang, et al 1998; Ang, Zhang, et al 1998; Ang et al 1999; Xu, Zheng, et al 1999; Peng et al 2001; Ang et al 2002). In contrast, 3 of 9 studies did not find that rCBF was significantly lower in the frontal lobe of patients with vascular dementia (VD) (Ang, Zhang, et al 1998; Ang et al 1999; Xu, Huang et al 1999).

Three articles showed that rCBF was also lower in the basal ganglia of patients with VD (Ang, Jiang, et al 1998; Xu, Zheng et al 1999; Peng et al 2001), but Xu, Huang et al (1999) found the same result only in patients with Parkinson's disease (PD), not in the VD group. Three authors found rCBF to be lower in the thalamus of VD patients (Ang, Jiang, et al 1998; Xu, Huang, et al 1999; Peng et al 2001), and 1 reported lower perfusion of rCBF in the hippocampus of AD patients (Peng et al 2001). There were 5 reports of lower rCBF in the occipital lobe (Liu et al 1997; Ang, Jiang, et al 1998; Ang, Zhang, et al 1998; Ang et al 1999; Xu, Huang, et al 1999), 4 in patients with VD and 1 in AD. rCBF in frontal, temporal, and parietal lobes in patients with AD was significantly lower than in patients with VD, some bilaterally and others in the right lobes only (Ang, Zhang, et al 1998; Ang et al 1999; Xu, Zheng, et al 1999).

Schizophrenia

Because 3 of the 13 papers about schizophrenia overlapped with other articles, we have included only 10 papers in Table 3. Most were controlled studies, with only 2 reports

on schizophrenia patients without controls (Li, Deng, et al 1996; Liu et al 1997). We found low rCBF in the frontal lobe of patients with schizophrenia in all 10 papers. Some were in the left frontal, others in the right, and some bilateral. Six studies reported lower rCBF also in the temporal lobe in schizophrenia (Li, Deng, et al 1996; Li, Tang, et al 1996; Li, Zhao, et al 1996; Li et al 2001, 2002; Liu et al 2002). Three authors found lower rCBF in the parietal lobe (Li, Deng, et al 1996; Zhou et al 2001; Liu et al 2002). Two reports found lower rCBF also in basal ganglia (Li, Zhao, et al 1996; Liu et al 2002), but there were only single reports of lower rCBF in the occipital lobe, thalamus, or cingulate respectively (Li, Deng, et al 1996; Zhou et al 2001; Liu et al 2002). Two reports measured changes of rCBF before and after antipsychotic treatment; 1 reported that rCBF increased by about 50% along with the positive symptoms but did not identify individual antipsychotics, while the other study detected no significant change after risperidone therapy for 8 weeks (Zhou et al 2001; Liu et al 2002).

We found only 1 paper on OCD, 1 in anxiety disorder, and 1 in heroin addicts (Table 4). rCBF was low in many brain regions such as frontal, temporal, parietal, occipital, thalamus, basal ganglia, vermis, pons, amygdala, precuneus, putamen, cingulated, and orbital gyrus. More studies are needed in these psychiatric disorders in patients in China.

Discussion

To date, only 6 SPECT studies have been made on depression in China. rCBF was significantly lower in many brain regions, eg, frontal, temporal, parietal, occipital, basal ganglia, cingulate, and thalamus. While all of the studies found rCBF to be low mainly in the frontal, and to be related to depression in the basal state, some researchers found rCBF to be lower in the right but others in the left or even to

Table 3 A review of SPECT studies on schizophrenia in China

Authors	Number and age	Duration and method	Diagnostic criteria and tools	rCBF results of patients
Li, Tang, et al (1996)	32 S G1, 14 18–54 yr G2, 18 25–58 yr 21 C 18–58 yr	G 1, 0.3–2.9 yr First time untreated G 2, 5–18 yr Treated ^{99m}Tc-ECD 1110 MBq Nickel's analysis	ICD-10 CCMD-2 CT	The abnormality of SPECT in group schizophrenia was 93.8% lower in bilateral frontal, left temporal lobes, and right basal ganglia in schizophrenia. Lower in left temporal than in right lobe within schizophrenia group.
Li, Deng, et al (1996)	9 S 31 ± 12 yr	20 d–17 yr No ^{99m}Tc-ECD 925–1225 MBq	CCMD-2	Low in right temporal in all patients. Low in bilateral temporal and frontal in 6 patients, and right parietal and left occipital in 4 patients.
Hu et al (1996)	22 S 18–42 yr 10 C 18–33 yr	6 m–21 yr ROI ^{99m}Tc-ECD 740 MBq	CCMD-2	4 patients with abnormal rCBF at baseline. Left frontal activation deficit.
Li, Zhao, et al (1996)	25 S1 (negative group) 16–54 yr 25 S2 (non-negative group) 18–58 yr 21 C	0.8–20 yr (9 ± 6 yr) 0.3–20 yr (5 ± 5 yr) Nickel's analysis ^{99m}Tc-ECD 1110 MBq	CCMD-2	Lower in frontal, temporal and basal ganglia in both groups than in control, but no significant differences within patients. No abnormalities in control group.
Liu et al (1997)	12 S 18–45 yr	No course recorded Drugs free within a month Pan's analysis ^{99m}Tc-ECD 12 mic–18 mic	DSM-IV CCMD-2-R WCST Andreasen's negative schizophrenia diagnostic criteria	Lower in left frontal than that of right lobe, no increase in left frontal lobe after WCST. Negative symptoms might be related to left frontal lobe.
Yu et al (1998)	22 S high negative group, 9, 31 ± 9 yr low negative group, 13, 29 ± 7 yr 10 C 26 ± 5 yr	0.5–9.9 yr ^{99m}Tc-ECD 740 MBq ROI analysis	CCMD-2 SANS BPRS WCST	Low in left frontal in both negative groups. Lower in right superior frontal in group of high score of SANS.

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Table 3 *continued*

Authors	Number and age	Duration and method	Diagnostic criteria and tools	rCBF results of patients
Li et al (2001)	24 S 18–50 yr 26 C 18–50 yr	10.8 ± 14.3 m untreated ^{99m}Tc-ECD 925–1110 MBq ROI analysis	ICD-10 SANS SAPS PANSS WCST	Before treatment with risperidone, rCBF was higher in bilateral inferior posterior temporal lobe at baseline, but lower in left mid-lateral frontal after cognitive activation. After treatment rCBF significantly lower in right lateral temporal, bilateral superior posterior temporal lobe. After cognitive activation rCBF increase in bilateral inferior medial frontal, left inferior lateral frontal, left superior fronto-temporal, and left superior lateral frontal.
Zhou et al (2001)	22 S Age 18–55 yr 10 C Age 21–47 yr	1–3 yr ^{99m}Tc-ECD 925–1110 MBq SPM ROI	CCMD-2-R	Abnormality in 82% (18/22). Lower in right frontal, parietal, temporal, and cingulate in schizophrenia group than in control. 8 patents tested before and after treatment, 100% abnormal before treatment, and 50% still abnormal after treatment. Significant changes in right frontal and temporal lobes.
Li et al (2002)	32 S 18–50 yr 26 C 18–50 yr	12.3 ± 20.0 m untreated ^{99m}Tc-ECD 925–1110 MBq ROI	ICD-10 Paranoid type WCST	The baseline ratio of rCBF was higher in bilateral inferior posterior temporal lobe but lower in right frontal-temporal and left mid-medial frontal.
Liu, Xiu, et al (2002)	21 S Age 52–76 yr (61 ± 7 yr) 20 C Age 54–75 yr (65 ± 5 yr)	6–54 m First episode late onset ^{99m}Tc-ECD 925–1110 MBq ROI RAR	DSM-III-R CT MRI MMSE WCST	Lower in left frontal, parietal, bilateral inferior temporal lobes, basal ganglia, right thalamus. Lower in left frontal than in right. RARS was not significantly changed in all regions after treatment with risperidone for 8 weeks in 11 patients.

Abbreviations: BPRS, brief psychiatric rating scale; CCMD-2-R, Chinese Classification of Mental Disorders-2-revision; CT, computerised tomography; C, controls; d, days; DSM-IV, Diagnostic and statistical manual of mental disorders fourth edition; G, group; ICD-10, the ICD-10 classification of mental and behavioural disorders, clinical description and diagnostic guideline; m, months; MMSE, MMSE, mini-mental state examination; MRI, magnetic resonance imaging; PANSS, positive and negative syndrome scale; RAR, radioactive ratios; ROI, regions of interest; SANS, scale for assessment of negative symptoms; SAPS, scale for assessment of positive symptoms; S, schizophrenia; SPM, statistical parametric mapping; WCST, Wisconsin card sorting test; yr, years.

be bilateral frontal. Most reported that rCBF was also low in temporal, parietal, and occipital lobes during depression. The results of low rCBF in frontal and temporal lobes in China are similar to those in North American and Japanese patients (Mayberg et al 1994; Ito et al 1996; Meltzer et al 1998; Nobler et al 1999). So it seems that the frontal cortex plays an important role in the expression of depression (Ariel et al 2004). Three reports about old patients with depression in Table 1 showed low rCBF low perfusion in basal ganglia (Jiang et al 2000; Zhao et al 2000; Ang 2003), which agrees with findings in North American patients (Buchsbaum et al 1997; Brody et al 2001). Only 1 paper (Deng et al 1997) found that low rCBF in cingulate was correlated with depression in Chinese patients, which supports the original results in North America of Austin et al (1992).

The first SPECT study in Alzheimer's disease (AD) was reported early in 1990 (Battistein et al 1990). Many nonChinese reports confirmed that perfusion of rCBF was significantly lower in temporal and parietal lobes of patients with AD (Formarelli et al 1996). Chinese studies in Table 2 showed that the rCBF was significantly lower in frontal, temporal and parietal lobe of patients with AD than that of control subjects. Some researchers found rCBF asymmetry in right and left; Ang, Jiang, et al (1998) reported that rCBF was lower in left than in right temporal lobe in AD, and lower in left than in right temporal, parietal, and occipital lobes in the VD group. Celsis et al (1997) considered that asymmetry of hypoperfusion in the temporal–parietal lobe was a predictor of cognitive defect to differentiate AD from aging-related cognitive changes in North American patients. Ang, Zhang, et al (1998) found that rCBF in AD was lower in bilateral frontal and right parietal lobes than in VD, but also reported lower perfusion of rCBF in the right temporal and right occipital in AD than that in VD; left parietal rCBF in AD was also higher than that of the VD group (Ang, Jiang, et al 1998).

Peng et al (2001) found the severity of AD to be associated with low perfusion of rCBF in the hippocampus. Four of 8 papers including VD patients did not show low rCBF in the frontal lobe (Jia et al 1996; Ang, Zhang, 1998; Ang et al 1999; Xu, Huang, et al 1999). Some investigators also found lower rCBF in the thalamus and basal ganglia in patients with VD (Liu et al 1997; Ang, Jiang, et al 1998; Xu, Huang, et al 1999; Peng et al 2001), but the results for the occipital lobe were contradictory.

Schizophrenia is a common disorder. According to the 10 papers listed in Table 3, all researchers found that rCBF perfusion was significantly lower in the frontal lobe of patients with schizophrenia, many of them showing problems also in the left side. Most of the studies (Jia and Gao 1996; Ang, Zhang, et al 1998) in Table 3 also showed lower rCBF occurring in the temporal lobe, with some reporting lower rCBF bilaterally and others finding it in the right or left temporal lobe; the results at present are inconsistent. These results are similar to those in nonChinese patients (Andreasen et al 1992; Wolkin et al 1992; Woods et al 1992). Li, Guifang, et al (1996) found that there was no significant difference between negative and positive symptoms in terms of lower perfusion of rCBF, both types being associated with lower rCBF in the brain, but Yu et al (1998) and Li et al (2001) reported that the negative symptoms of schizophrenia might be related to the perfusion of rCBF in the left frontal lobe. Andreasen et al (1992) and Rubin et al (1994) found similar results in nonChinese patients.

After treatment with risperidone, Li et al (2001) found that perfusion in the thalamus and superior posterior temporale was decreased significantly, with parallel improvement in positive symptoms, similar to that in nonChinese reports (Berman et al 1996; Sabri et al 1997; Malaspina et al 1999; Puri et al 2001).

For late-onset schizophrenia, Liu et al 2002 found lower rCBF in the left frontal, left parietal, bilateral temporal, bilateral basal ganglia, and right thalamus (Liu et al 2002), similar to the nonChinese results of Lesser et al (1993), Dupont et al (1994), and Sachdev et al (1997).

There were few studies of other mental disorders in China, with only 1 paper on OCD, one on anxiety disorders, and one on heroin addicts (Table 4). Li et al (2002) found that the results of rCBF were different with different ways of analysis, rCBF being lower in the right anterior temporal, temporo-parietal, and left temporo-occipital lobes of patients with OCD using the regions of interest (ROI) method, but low in bilateral putamen, superior temporal gyrus, precuneus, right orbital gyrus, superior and middle frontal gyrus, left temporo-occipital lobes, superior parietal gyrus, vermis with SPM analysis. Wan et al (2002) found that rCBFs of brain were generally decreased under stressor stimulation, similar to the findings in nonChinese patients of Lucky et al (1997). Wan et al (2002) did not find low

Table 4 A review of SPECT studies on other mental disorders in China

Authors	Number and age	Duration and method	Diagnostic criteria and tools	rCBF results of patients
Li, Jiang, et al (2002)	14 OCD (30 ± 12 yr) 23 C no record	No record ^{99m}Tc-ECD 740 MBq SPM and ROI	ICD-10 Yale Brown obsessive-compulsive scale	Low in bilateral putamen, superior temporal lobe, gyrus, precuneus, right orbital gyrus, superior and middle frontal gyrus, left temporal-occipital lobe, superior parietal gyrus, and vermis with SPM analysis. Low in right anterior temporal lobe, temporal-parietal lobe, and left temporal-occipital lobe with ROI analysis.
Wan et al (2002)	20 ANX 25–63 yr 20 C 22–60 yr	No record ^{99m}Tc-ECD 925–1110 MBq ROI	CCMD-2-R HAMA HAMD	Lower in frontal, temporal lobes, thalamus and basal ganglia at baseline state. Lower in pons, frontal, temporal, parietal, occipital lobes, thalamus, and basal ganglia during stress condition. Significant increase in all regions of patients after modified stressor stimulation.
Wang et al (2003)	25 ADI 20–45 yr	No record ^{99m}Tc-ECD 925–1110 MBq ROI and RAR	DSM-IV	Increase in frontal, temporal lobes, and amygdala during exposure to heroin-related cues.

Abbreviations: ADI, heroin addict; ANX, anxiety disorder; CCMD-2-R, Chinese Classification of Mental Disorders-2-revision; DSM-IV, Diagnostic and statistical manual of mental disorders fourth edition; HAMA, Hamilton anxiety scale; HAMD, Hamilton depression scale; ICD-10, The ICD-10 classification of mental and behavioural disorders, clinical description and diagnostic guideline; OCD, obsessive compulsive disorder; RAR, radioactive ratios; ROI, regions of interest; yr, years.

Table 5 A comparison of rCBF distribution of SPECT in depression, AD, VD, and schizophrenia

Items	Depression	AD	VD	Schizophrenia
Frontal	++++	++++	++	++++
	Asymmetry in right or left	Asymmetry in right or left		Asymmetry in right or left
Temporal	+++	++++	++++	+++
Parietal	+++ old patient	++++	++++	++
Occipital	+++	+	+++	+
Thalamus	+	?	+++	+
Basal ganglia	++ old patient	?	+++	+
Cingulate	+	?	?	+
Hippocampus	?	+	?	?

Abbreviations: AD, Alzheimer's disease; VD, vascular dementia.

perfusion in the cerebellum, but Bonne et al (2003) found the abnormality in nonChinese PTSD patients. Wang et al (2003) indicted that frontal, temporal, and amygdala rCBF changes were associated with relapsing processes during exposure to heroin-related cues.

According to all the above studies, we found that perfusion of rCBF was abnormal in mental disorders, but the specificity of the abnormality is not consistent. From Table 5, we know that lower rCBF could be seen mostly in frontal, temporal, and parietal lobes of patients with depression, AD, schizophrenia, and VD. It seems that the abnormality of the frontal lobe is more common in depression and schizophrenia, but temporal lobe abnormality is more common in AD and VD. The perfusion of rCBF in the parietal lobe seems related to aging, because older patients seem to have lower perfusion of rCBF. The abnormality in the occipital lobe and basal ganglia seems to have an association with vascular problems according to the results presented in Table 5, supporting the hypothesis of vascular depression for old patients. The problem in the thalamus was correlated mainly with VD, and in the cingulate largely with depression and schizophrenia. One paper found AD associated with the hippocampus. There were few reports of anxiety disorders and other mental problems. It seems likely that brain abnormalities in Chinese psychiatric patients are similar to those in nonChinese populations, at least as measured by rCBF changes in SPECT studies. We need multicenter, large-sample, same-diagnosis-criteria, prospective, controlled, collaborative studies across populations to provide more specific information on the pathophysiology in mental disorders.

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