

## Case Reports of Unexpected Suicides in Patients within Six Months after Stroke

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### ABSTRACT

**Suicide after stroke is a grievous occurrence. Since the majority of cases under study had shown signs of recovery from stroke, persons surrounding these patients were severely shocked by these suicides. Six patients who attempted suicide within six months after stroke were investigated to determine factors following stroke that relate to suicide in order to prevent future post-stroke suicides. Clinical findings in these six cases were retrospectively analyzed in collaboration with stroke neurologists and coworkers caring for these patients. Four of six patients had sustained a recent infarction extending from the temporal cortex to the parietal cortex. Four of six patients showed depression, and five of six patients showed moderate disability after stroke. Physicians should carefully observe patients with infarction extending from the temporal cortex to the parietal cortex, depression and moderate disability, in order to prevent suicidal behavior.**

### INTRODUCTION

The underlying causes of suicide have generally been associated with social situations (1), mental problems (2, 3) and genetics (4). To date, several studies of brain abnormalities related to suicide analyzed postmortem findings in suicide victims (5-7). These studies showed that disorders of the serotonergic system in the prefrontal cortex and brain stem are key issues in suicidal behavior. Furthermore, patients with temporal lobe epilepsy have been reported to show a tendency toward suicide attempts (8-10). Stroke patients commonly develop depression and may have suicidal ideation (11-16), but rarely attempt suicide in the early stage following stroke (17). We analyzed and compared six patients who attempted suicide within six months after stroke, and discuss measures to prevent suicide.

### METHODS

Two authors (MK, HN) collected data from six cases that met the following conditions from eleven stroke neurologists working in six different institutions. The conditions were that the patients in these cases suffered a stroke between 1999 and 2006 and were rescued from stroke, but they committed or attempted suicide within six months after stroke.

Since the authors (MK, HN) hypothesized that these cases might have been undergoing similar organic processes that influenced attempts at suicide, a collaborative analysis of the clinical findings in these six cases was performed retrospectively. The families of the patients, employees of the chronic care facilities at which the patients committed or attempted suicide, and patients who survived were interviewed to obtain detailed information regarding the suicidal behavior.

## RESULTS

Six right-handed patients with brain infarction attempted suicide, and two of these patients survived. None was diagnosed with depression prior to stroke.

In these patients, brain areas that were damaged by stroke just before the suicide attempt are shown in Figure 1.

### Case 1

The patient in Figure 1a (Table I-III) was a 60-year-old man transported to an emergency department due to the sudden onset of right-sided motor weakness and speech difficulty. On admission, his consciousness level was 10 on the Japan Coma Scale (JCS) (18). He did not speak spontaneously but could understand simple instructions. Neurological examinations showed conjugate gaze deviation to the left, right facial paresis, right hemiparesis and right hemi-sensory impairment. Electrocardiograms (ECG) showed atrial fibrillation. Cranial MRI demonstrated a recent infarction extending from the temporal cortex to the parietal cortex on the left side (Fig. 1a). Starting on the fourth hospital day, he repeatedly showed episodes of decreased consciousness, conjugate gaze deviation to the right and aggravation of right hemiparesis. Head CT scan did not detect hemorrhagic changes or new infarcted lesions. Cranial MRI also failed to demonstrate relapse of infarction. Based on neurological and neuroimaging findings, he was diagnosed as having early seizures with a focus at the left parieto-temporal region, although EEG failed to detect epileptic discharges. There were no further attacks after carbamazepine administration. On the 124<sup>th</sup> hospital day, the patient abruptly escaped from the hospital without being discharged. The following day, the patient committed suicide by jumping in front of a moving train. The patient had usually smiled pleasantly following stroke and had not shown any abnormal behavior suggestive of suicide, although one attending physician reported after the suicide that the patient had occasionally appeared depressed and lonely.

The patient did not have a previous history of depression or other psychiatric disorder and there was no history of suicidal behavior or psychiatric disorder among his relatives. There was no apparent presence of family support and he had not received treatment for depression before suicide, as signs of depression were not apparent. The modified Rankin scale (mRS) (19) was 0 before stroke, but increased to 3 after stroke. He had a history of urinary stone. Stroke had occurred in February and he committed suicide in June.

### Case 2

The patient in Figure 1b (Table I-III) was an 86-year-old woman. Her family noticed speech abnormality and brought her to the hospital. On admission, there were no abnormalities in motor function or sensation. She demonstrated Wernicke's aphasia, although she could understand simple instructions. Cranial MRI showed a recent infarction extending from the temporal cortex to the parietal cortex on the left side (Fig. 1b). She was discharged from hospital one month after stroke. She began to complain of occipital headache two months after infarction and requested treatment five times. On the 99<sup>th</sup> day after stroke, she attempted suicide by drinking kerosene. She was, however, immediately transported to an emergency department and survived. The event was totally unpredicted by her doctors, nurses and family. After the attempt at suicide, she was referred to a psychiatrist and was diagnosed as having post-stroke depression.

The patient did not have a previous history of depression or other psychiatric disorder and there was no history of suicidal behavior or psychiatric disorder among her relatives. Her daughter provided support for her mother, but the patient had not received treatment for

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depression before suicide, as there were no apparent signs depression. The score on mRS (19) was 2 before stroke, but increased to 3 after stroke. She had a history of cataract and constipation. Stroke occurred in February and the patient attempted suicide in May.

### Case 3

The patient in Figure 1c (Table I-III) was a 63-year-old man. On arising, he noticed left-sided weakness and slurred speech, and was transported to an emergency department. On admission, his consciousness level was 1 on JCS. Neurological examinations showed left facial paresis, left hemiparesis, dysarthria, dysgraphia, and left unilateral spatial neglect. Cranial MRI demonstrated a recent infarction extending from the temporal cortex to the parietal cortex on the right side (Fig.1c). He was discharged from hospital on the 34<sup>th</sup> day after stroke.

He could not return to his previous work due to residual neurological deficits and stayed at home after discharge. He committed suicide by hanging himself on the 57<sup>th</sup> day after infarction. His family and friends had never recognized any signs of depression. This patient (Fig. 1c) had a history of infarctions in the right superior parietal lobe and right basal ganglia. He had exhibited agraphia following the previous stroke, although the lesion was located in the right cerebral hemisphere, suggesting partial dominance of the right cerebral hemisphere.

The patient did not have a previous history of depression or other psychiatric disorder and there was no history of suicidal behavior or any psychiatric disorder among his relatives. His wife provided support. He did not receive treatment for depression before suicide, as he had not been diagnosed as having depression. The score on mRS (19) was 0 before stroke, but increased to 2 after stroke. He had a history of hypertension. Stroke occurred in April and he committed suicide in June.

### Case 4

The patient in Figure 1d (Table I-III) was an 81-year-old man. On arising, he recognized severe left-sided hemiparesis and was transported to a hospital. On admission his consciousness level was 2 on the JCS. Neurological examinations demonstrated left facial paresis, left hemiparesis, dysarthria and aphasia. The eyes deviated slightly to the right. Cranial MRI showed a recent infarction extending from the temporal cortex to the parietal cortex on the right side (Fig. 1d). Starting on the 17<sup>th</sup> hospital day, he became depressed and expressed suicidal ideation. On the 18<sup>th</sup> hospital day administration of paroxetine and clonazepam were initiated to treat depression. On the 25<sup>th</sup> hospital day, he said, "I want to die". That night, he tried to open the 10<sup>th</sup> floor window, began to climb on the window-still and attempted to jump. However, a nurse found him almost immediately and prevented the suicide. This patient had an old infarction of the left frontal cortex and demonstrated mild aphasia.

He was in the recovery stage of transcortical motor aphasia at the time of the last stroke. The patient did not have a previous history of depression or other psychiatric disorder and there was no history of suicidal behavior or any psychiatric disorder among relatives. His wife supported him. The score on mRS (19) was 2 before stroke, but increased to 3 after stroke. He had a history of hypertension and atrial fibrillation. Stroke occurred in June and he attempted suicide in July.

### Case 5

The patient in Figure 1e (Table I-III) was a 71-year-old man with an old infarction in the left frontal lobe. He suddenly felt dizzy and could not continue to stand by himself, and then

he developed severe amnesia. He also exhibited dyslexia, alexia and anomia, although there was no motor weakness. His type of speech disturbance could not be analyzed in detail because he demonstrated perseveration. Cranial CT demonstrated recent infarcted lesions at the left occipital cortex and interior of the left temporal cortex. He was discharged from hospital on the 42<sup>th</sup> day after stroke. He demonstrated a surfeit of anxiety about his condition. In addition, he complained of fatigue and expressed a feeling of being “washed out” prior to his suicide. On the 56<sup>th</sup> day after infarction, he committed suicide by hanging himself at his home. Neither Case 4 nor Case 5 had discussed suicidal ideas with any other persons, although both of them had appeared depressed. The patient did not have a previous history of depression or other psychiatric disorder and there was no history of suicidal behavior or psychiatric disorder among his relatives. His wife provided support. He had been prescribed etizolam to treat his depression 42 days before suicide. The score on mRS (19) was 0 before stroke, but increased to 3 after stroke. He had a history of atrial fibrillation, hypertension and hyperlipidemia. Stroke occurred in February and he committed suicide in April.

### **Case 6**

The patient was a 63-year-old man. He had old infarctions involving the basal ganglia bilaterally and in the left pons. He showed sudden onset of dysarthria six months prior to suicide. No new infarcted lesion could be identified on CT, MRI or SPECT. Judging from the neurological manifestation, pure dysarthria, recurrent infarction in the corona radiata or medial pons was suspected. He was discharged from hospital on the 33<sup>rd</sup> day after stroke. After discharge, his behavior caused problems at work and he became depressed. On the 176<sup>th</sup> day after infarction, he committed suicide by hanging himself at his house. The patient did not have a previous history of depression or other psychiatric disorder and there was no history of suicidal behavior or psychiatric disorder among his relatives. His wife provided support. He was not prescribed medication for depression before suicide, as the symptoms of depression were mild. The score on mRS (19) was 0 before stroke, but increased to 1 after stroke. He had a history of hypertension, hyperlipidemia, hyperuricemia and diabetes mellitus. Stroke occurred in November and he committed suicide in May.

We did not insert the brain imaging of Case 6 in Figure 1 because we could detect the area of the brain that was damaged by stroke in Case 6 just before the suicide.

## **DISCUSSION**

It has been reported that the suicide rate increases following stroke (20-22). In this regard, one of the authors (MK) became very concerned about suicidal behavior following stroke after encountering a patient who attempted suicide several months after stroke. In discussing this experience with another author (HN), both were surprised that there had been similar experiences in the second author’s department almost one year earlier. Thereafter, three of the neurologists (OM, MN, KA) indicated that they had encountered cases of suicide following stroke. While data were being collected from these neurologists, HN encountered another patient who attempted suicide. We analyzed six cases that we presented here over the course of five years, in collaboration with doctors from six hospitals specializing in the care of stroke patients. The number of fresh stroke patients treated in these hospitals was roughly 8000 cases. To investigate the causes underlying attempts at suicide in our series, we compared our cases to previous reports of suicide in the general population and in stroke patients. The suicide rate (per 100,000) in Japan was 17.2 in 1995, 24.1 in 2000, 25.5 in 2003 (23,24). If the population size of our case were converted from 8000 to 100,000, the suicide

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rate (per 100,000) patients 6 months after stroke would reach 75, indicating that the suicide rate in our series was greater than the suicide rate in the general population.

It was previously reported that the suicide rate in the general population is highest among the elderly, but recently the suicide rate has risen in the younger population and decreased among the elderly (25-27). In suicide after stroke, the suicide rate is higher among younger patients (under age 60) (20, 21). In this series, patient ages (Table I) were all over 60, and the mean  $\pm$  standard deviation for patient age in our series was  $70.7 \pm 10.7$ . Furthermore, the number of males (five patients) was higher than that of females (one patient). This suggests an important finding for clinical staff to prevent suicide attempts by patients with stroke, although we could not draw definitive conclusions about the suicide rate by age and gender based only on our cases.

In the general population, it was reported that the suicide rate is highest in the spring, but the pattern has recently changed (25,28). The time of year (Table I), when our patients attempted suicide was concentrated between April (spring) and July (summer). In Japan, the onset of stroke is higher in the winter and spring than in the summer (29). In our cases, the incidence was also concentrated between winter and spring (Table I). This may have affected the time of suicidal attempts in our series.

It is difficult for patients with severe impairment after stroke to attempt suicide. The level of strength in patients after stroke is an important factor in attempting suicide. Furthermore, it was reported that when the duration of in-hospital treatment is relatively short, the risk of suicide is greater (21). In our case, the duration of hospitalization was generally less than two months, except in Case 1. In that case, the duration of hospitalization was prolonged because it was difficult to find a person who would provide support for the patient. As shown in Figure 2, the functional disabilities (mRS) in our cases after stroke were increased to 3. These findings were almost in agreement with those of the previous report (21).

Motor disabilities and cognitive disorder after stroke induce depression and social isolation. These factors were also reported to increase the risk of suicide (20, 22, 30). As shown in Table II, five of our patients could not work after stroke. The functional disability of Case 6 was mild, but depression developed (Table III).

A change in mood could induce suicide. Therefore, depression and suicidal plan are important factors associated with suicide after stroke (22). The majority of mood disorders in patients after stroke involve post-stroke depression. Post-stroke depression occurs in 29.7% of patients within one month after stroke (31), and suicidal ideation is present in 9.8% of patients three months after stroke (12). In our study, four patients (66.6%) showed symptoms of depression (Table III) and one patient (16.7%) expressed suicidal ideation. Therefore, we should take note of depression in patients after stroke, and should also monitor patients with depression despite the absence of apparent suicidal ideation.

Patients express emotional changes such as depression in their speech, behavior and appearance. Individuals surrounding the patients may perceive suicidal intent and depression more acutely through words rather than through actions. However, some patients develop aphasia after stroke, and can not express their emotional state using speech.

For example, case 1 (Table III) had severe aphasia. Only one physician interpreted his sighing as a sign of depression, but even this physician could not truly understand the patient's deep feelings partly due to aphasia. Case 2 (Table III) also had severe aphasia. She repeatedly complained of headache prior to the suicide. These complaints might suggest a depressive state, but no one noticed signs of emotional change. Case 3 did not exhibit aphasia or show any signs of depression. Case 4 (Table III) had mild aphasia and showed signs of a mild depressive episode. Case 5 (Table III) not only showed anomia but also

exhibited a mild depressive episode. One patient (Case 6: Table III) without aphasia also exhibited a mild depressive episode. The majority of patients without aphasia or with only mild aphasia were able to express their emotional state, and hence persons around the patients could more easily notice changes in their expressed emotions. Such patients should receive anti-depressant medication at an early stage and may not go on to attempt suicide (32). However, patients with severe aphasia (Cases 1, 2) likely have difficulty in expressing their emotions, and hence persons surrounding such patients tend to miss the emotional change. These findings suggest that we should carefully observe patients with depression or aphasia.

None of our patients had either a past history or family history of depression (Table III). Only one patient (Case 1) did not have any family support (Table III). He did not show an attitude suggesting depression.

Kishi et al. (33) studied the relationship between a suicidal plan and lesions. They found that a suicidal plan after stroke is associated with the anterior area of the cortex during the early stage of stroke, but is associated with the posterior area of the cortex during the late stage. The majority of stroke patients cannot move by themselves during the early stage of stroke and hence are unlikely to engage in suicidal behavior, even if they have a plan to commit suicide. In the current series, all six patients attempted or committed suicide 1-6 months after stroke. Such late timing to the suicidal behavior may be attributable to the fact that more than one month was required to develop suicidal behavior. Bogousslavsky et al. documented that the death rate did not increase among patients with mood disorders following stroke (34). However, they did not focus on lesions of the temporo-parietal cortex or any other specific region (34).

In our series, four (Cases 1-4) of six patients experienced a recent infarction extending from the temporal cortex to the parietal cortex. The remaining two patients (Case 5, 6) did not have infarction extending from the temporal cortex to the parietal cortex. Therefore, there were four cases (66%) that had stroke extending from the temporal cortex to the parietal cortex among our cases. The suicide rate (per 100,000) was roughly 50. This showed that the suicide rate for patients with stroke extending from temporal cortex to parietal cortex was also higher than that in the general population (23,24). According to the report of Bogousslavsky(35), the rate of stroke involving the middle cerebral artery, which caused a lesion from the temporal cortex to parietal cortex were 25% (Deep+pial MCA(8%), Pial MCA lower division(14%) and large(3%)). We consider these findings, and we think the frequency of suicide among our cases was higher and has significance. However, we cannot conclude that the lesion triggered suicide based solely on these data. The relationship between post-stroke suicide and the area of stroke lesion should be a key issue in a future study.

All six patients reported in this study had brain infarction but not brain hemorrhage. According to data obtained by one of the departments collaborating in this study, 353 stroke patients were admitted in 2000, and 307 of them (87%) had brain infarction (31). Furthermore, 89 of 105 stroke patients with depression (85%) had brain infarction (31). These data suggest that patients with infarction were dominant in our series.

In this series, the majority of patients who attempted suicide demonstrated depression, aphasia and brain infarction in the temporo-parietal cortex.

These were tendency within our cases that we had investigated in this series, but these results included the indication to protect the patient after stroke from the suicide. In conclusion, it should be kept in mind that patients with brain infarction in the temporo-parietal cortex may harbour a hidden suicidal desire and may be unable to express

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that desire. Special attention should be paid to observation of such patients in order to prevent unexpected suicidal behavior.

**Table I.** Age, gender and time course for each patient.

Winter is defined as including December, January and February; spring is defined as March, April and May; summer as June, July and August; autumn as September, October and November. Interval indicates the time between infarct and suicide attempt.

	Age (year)	gender	Month and season of stroke	Month and season of suicidal attempt	Duration of hospitalization (days)	Interval from stroke to suicide attempt (days)
<b>Case 1</b>	60	Male	February/winter	June/summer	125	125
<b>Case 2</b>	86	Female	February/winter	May/spring	28	99
<b>Case 3</b>	63	Male	April/spring	June/summer	34	57
<b>Case 4</b>	81	Male	June/summer	July/summer	25	25
<b>Case 5</b>	71	Male	February/winter	April/spring	42	56
<b>Case 6</b>	63	Male	November/autumn	May/spring	33	176

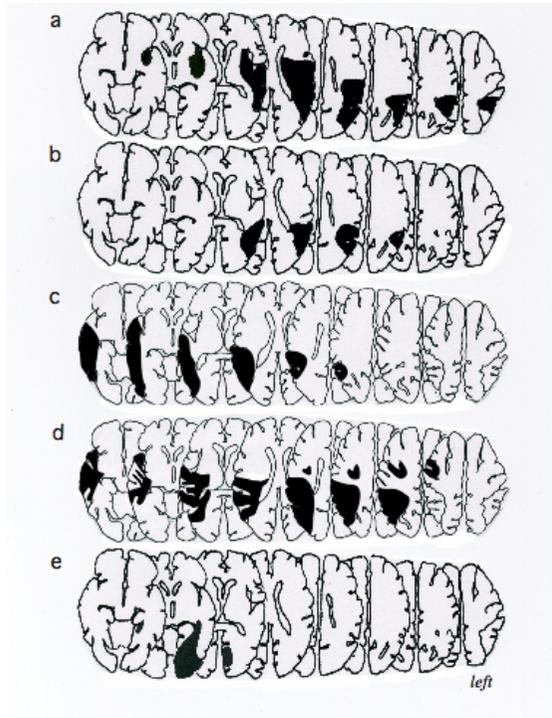
**Table II.** Neurological disturbance in the each patient.  
mRS indicates the modified Rankin Scale.

	Aphasia	Type of aphasia Main neurological disturbance except aphasia	mRS before stroke	mRS after stroke
<b>Case 1</b>	Atypical aphasia	Right hemiparesis	0	3
<b>Case 2</b>	Wernicke's aphasia	none	2	3
<b>Case 3</b>	none	Left hemiparesis	0	3
<b>Case 4</b>	Recovery stage of transcortical motor aphasia	Left hemiparesis	2	3
<b>Case 5</b>	Anomia	Amnesia, dyslexia	0	3
<b>Case 6</b>	none	dysarthria	0	0

**Table III.** The status of depression in the each patient.

Depressive episodes before attempt at suicide were evaluated by ICD-10.

	Depressive episode (ICD-10)	Prescription for depression	History of depression	Family history of depression	Family support
<b>Case 1</b>	none	none	none	none	none
<b>Case 2</b>	Other depressive episode (F32.8)	none	none	none	daughter
<b>Case 3</b>	none	none	none	none	wife
<b>Case 4</b>	Mild depressive episode (F32.0)	Paroxetine and clotiazepam	none	none	wife
<b>Case 5</b>	Mild depressive episode (F32.0)	etizolam	none	none	wife
<b>Case 6</b>	Mild depressive episode (F32.0)	none	none	none	wife



**Figure 1.** Lesions of the cortex due to recent stroke just before the suicide. (a-d) Stroke damage in these regions was plotted using MRI-flair images on axial templates (36). (a) Case1: MRI scan obtained three days after the onset of stroke. (b) Case 2: MRI scan obtained five days after the onset of stroke. (c) Case 3: MRI scan obtained two days after the onset of stroke. (d) Case 4: MRI scan obtained 12 days after the onset of stroke. (e) Case 5: Stroke damage in these regions was plotted from CT images on axial templates (36). CT scan obtained one day after the onset of stroke.

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### REFERENCES

1. **Jamison, K. R.** (1999). Night falls fast (Diane Publishing Co.).
2. **Jameison, G. R.** (1936). Suicide and mental disease. *Archives of Neurology and Psychiatry* **36**:1-12.
3. **Heeringen, C. V. and Marusic. A.** (2003). Understanding the suicidal brain. *Br. J. Psychiatry* **183**:282-284.
4. **Roy, A., Segal, N. L., Centerwall, B. S and Robinette, C. D.** (1991). Suicide in twins. *Arch. Gen. Psychiatry* **48**:29-32.
5. **Arango, V., Underwood, M. D. and Mann, J. J.** (1997). Postmortem findings in suicide victims. *Ann. N. Y. Acad. Sci.* **836**:269-287.
6. **Mann, J. J.** (1998). The neurobiology of suicide. *Nature Med.* **4**: 25-30.
7. **Arango, V., Huang, Y.-Y., Underwood, M. D. and Mann, J. J.** (2003). Genetics of the serotonergic system in suicidal behavior. *J. Psychiatr. Res.* **37**:375-386.
8. **Fukuchi, T. et al.** (2002). Death in epilepsy with special attention to suicide cases. *Epilepsy Res.* **51**:233-236.
9. **Jensen, I. and Larsen, J. K.** (1979). Mental aspects of temporal lobe epilepsy. *J Neurol. Neurosurg. Psychiatry* **42**:256-265.
10. **Brugger P., Agosti, R. Regard, M., Wieser, H.-G. and Landis, T.** (1994). Heautoscopy, epilepsy, and suicide. *J Neurol. Neurosurg. Psychiatry* **57**: 838-839.
11. **Ghika-Schmid, F and Bogousslavsky, J.** (1997). Affective disorders following stroke. *Eur. Neurol.* **38**:75-81.
12. **Pohjasvaara, T., Vataja, R., Leppävuor, A., Kaste, M. and Erkinjuntti, T.** (2001). Suicidal ideas in stroke patients 3 and 15 months after stroke. *Cerebrovasc. Dis.* **12**:21-26.
13. **Carota, A., et al.** (2005). A prospective study of predictors of poststroke depression. *Neurology* **64**:428-433.
14. **Carod-Artal, F. J.** (2007). Are mood disorders a stroke risk factor? *Stroke* **38**:1-3.
15. **Carod-Artal, F. J.** (2006). Post-stroke depression (II): its differential diagnosis, complications and treatment. *Rev. Neurol.* **42**:238-244.
16. **Robinson, R. G., Starr, L. B., Lipsey, J. R., Rao, K. and Price. T. R.** (1984). A two-year longitudinal study of post-stroke mood disorder: dynamic changes in associated variables over the first six months of follow-up. *Stroke* **15**:510-517.
17. **Teasdale, T. W. and Engberg, A.W.** (2001). Suicide after a stroke: a population study. *J. Epidemiol. Community Health* **55**:863-866.
18. **Sakai K, Iwahashi K, Terada K, et al.** Outcome after external decompression for massive cerebral infarction. *Neurol Med Chir.* 1998;**38**:131-136.
19. **Quinn, T.J., Dawson, J., Walters, M.R. and Lees, K.R.** (2009). Reliability of the modified rankin scale-A systematic review. *Stroke* **40**:3393-3395.
20. **Stenager, E.N., Madsen, C., Stenager, E. and Boldsen, J.** (1998). Suicide in patients with stroke: epidemiological study. *BMJ* **316**:1206.
21. **Teasdale, T.W. and Engberg, A.W.** (2001). Suicide after a stroke: a population study. *J.*

- Epidemiol. Community Health **55**:863-866.
22. **Arciniegas, D.B. and Anderson, C.A.** (2002). Suicide in neurologic illness. *Curr. Treat. Options Neurol.* **4**:457-468.
  23. Health and Welfare Statistics Association in Japan (2005). 5<sup>th</sup> Statistics concerning suicide deaths-special report on demographic statistics.
  24. **Kishi, Y. and Kathol, R.G.** (2002). Assessment of patients who attempt suicide. *Primary Care Companion J. Clin. Psychiatry* **4**:132-136.
  25. **Hawton, K. and van Heeringen, K.** (2009). Suicide. *Lancet* **373**:1372-1381.
  26. **Prithard, C. and Hansen, L.** (2005). Comparison of suicide in people aged 65-74 and 75+ by gender in England and Wales and the major Western countries 1979-1999. *Int. J. Geriatr. Psychiatry* **20**:17-25.
  27. Health and Welfare Statistics Association in Japan (2005). 5<sup>th</sup> Statistics concerning suicide deaths-special report on demographic statistics.
  28. **Yip, P.S.F., Chao, A. and Chiu, C.W.F.** (2000). Seasonal variation in suicides: diminished or vanished. Experience from England and Wales, 1982-1996. *Br. J. Psychiatry* **177**:366-369.
  29. **Wang, H., Sekine, M., Chen, X. and Kagamimori, S.** (2002). A study of weekly and seasonal variation of stroke onset. *Int. J. Biometeorol.* **47**:13-20.
  30. **Garden, F.H., Garrison, S.J. and Jain, A.** (1990). Assessing suicide risk in stroke patients; review of two cases. *Arch. Phys. Med. Rehabil.* **71**:1003-1005.
  31. **Naritomi, H.** Post-stroke depression. *Recent Advances in Cardiovascular Disease* **22**: 13-20 (2001).
  32. **Baldessarini, R. J., et al.** (2007). Ecological studies of antidepressant treatment and suicidal risks. *Harv. Rev. Psychiatry* **15**:133-145.
  33. **Kishi, Y., Robinson, R. G. and Kosier, J. T.** (1996). Suicidal plans in patients with stroke: comparison between acute-onset and delayed-onset suicidal plans. *International Psychogeriatrics* **8**:623-634.
  34. **Bogousslavsky, J.** (2003) William Feinberg Lecture 2002 emotion, mood, and behavior after stroke. *Stroke* **34**:1046-1050.
  35. **Bogousslavsky, J.** (1991). Topographic patterns of cerebral infarcts. *Cerebrovasc. Dis.* **1**(suppl 1): 61-68.
  36. **Damasio, H. and Damasio, A. R.** (1989). *Lesion analysis in Neuropsychology* (Oxford Univ. Press, New York).