Distributions of Lesions in Hanging Suicide Brains

By

Hui Jing HE, Noboru GOTO, Jun GOTO, Hiromitsu EZURE and Eiji TAKAOKI

Department of Anatomy, Showa University School of Medicine, 5-8, Hatanodai 1, Shinagawa-ku, Tokyo 142-8555, Japan

- Received for Publication, January 25, 2002 -

Key Words: Hanging suicide, Cerebral blood vessels, Brain edema, Pathology, Venous drainage

Summary: We found a morphological similarity in the distribution of vascular lesions in five hanging suicide brains. The overall findings on the lesions remind us of the venous origin but not of the arterial origin of the blood supply. Morphometric evaluations did not reveal any valuable conclusion. The results of this pathological research may be of clinical importance for the treatment of hanging patients.

Hanging is a not uncommon method of suicide. It is said that in that case death is caused by upper airway occlusion and carotid artery obstruction. Furthermore, hanging is a form of strangulation in which compression on the neck causes a ligature which is then tightened by the body weight. It may cause multifactorial hypoxic damage to the central nervous system, for example airway obstruction with systemic hypoxia, or sudden arrest of circulation and oxygenation to the brain or cardiac arrest as a result of compression of the nerves and vessels on the neck causing shock (vague inhibition). As far as we know, no study of morphological changes in hanging suicide brains have so far been conducted. This paper reports on the nature and distribution of lesions in five hanging suicide brains.

Methods

The cadavers were donated to us by the bereaved families within 12 hours for anatomical dissections for the purpose of education and research after medical inspections regarding the cause of death by police medical examiners. The time of death was estimated within 24 hours due to suicide hanging by them. Five human brains (3 males, 2 females) were removed from cadavers of suicides by hanging after immediate injection of 10% formalin through the femoral and the common carotid arteries for fixation using a pulsation pump with the opening of the femoral and jugular veins for drainage of blood. We know from our experience with the dissection of more than 1,000 cadavers that this injection method does not affect the brain volumes. The surface structures of the brains were carefully observed and pictures were taken after removing them from the skull.

The brains were cut to make coronal or horizontal slices of 10 mm thickness in order to observe the distribution of the lesions and to calculate parameters such as the volume of the cortex or the white matter.

For the measurement of the cerebral cortex and medulla, the sections were traced using a digitizer (Wacom Co, Digitizer SD421A, Saitama) and a computer (NEC, PC9821V13, Tokyo) to calculate the area of those sections with the use of original software.

For microscopic observation of the hanging brains, some of the brain slices were then fixed in a secondary fixative composed of 5% potassium dichromate ($K_2Cr_2O_7$) and 5% potassium chromate ($K_2CrO_4$), 1:4 in volume and kept for 2 weeks at room temperature, followed by fixation in a fresh fixative of the same composition at 37°C for an additional week. After washing in running water
and dehydration in graded alcohol, the blocks were embedded in celloidin to be cut at 30 μm thickness and stained with Luxol fast blue-periodic acid-Schiff-hematoxylin (LPH) triple stain, Klüver-Barrera’s (KB) stain or HE stain.

Results

Data for subject identification (subject's number, age and sex), brain weight after fixation in 10% formalin and distribution of the lesion are given below. In this connection, there was no marked abnormality of the arterial and venous systems in these brains.

AS-1427; Age: 60; Sex: male; Brain weight: 1,190 g
Distribution of the lesion: There were no macroscopic abnormalities in the cerebral hemispheres. There were, however, perivenous pale areas under the microscope (Figs. 1 and 2).

AS-1603; Age: 73; Sex: male; Brain weight: 1,450 g
Distribution of the lesion: There was slight bilateral swelling of the white matter (centrum semiovale) extending from the frontal to occipital lobes (Fig. 3).

AS-1499; Age: 79; Sex: female; Brain weight: 1,100 g
Distribution of the lesion: There was bilaterally symmetrical swelling of the white matter (centrum semiovale) extending from the frontal to occipital lobes (Fig. 4). The swelling with demyelination of the white matter was most severe in the parietal lobes (Fig. 5).
Fig. 4. Distribution of symmetrical severe swelling lesions in the cerebral medullary substance. AS-1499.

Fig. 5. Coronal section of the cerebral hemisphere showing severe swelling with demyelination. KB stain, LV: lateral ventricle.

Fig. 6. Distribution of symmetrical slight destructive lesions in the cerebral medullary substance. AS-1344.

Fig. 7. Coronal section of the cerebral hemisphere showing partial myelin destruction but no swelling. LPH stain. D: destruction, LV: lateral ventricle, SPC: Splenium of the corpus callosum.
Distribution of the lesion: There were bilaterally symmetrical subcortical destructive lesions extending from the frontal to occipital lobes in the white matter (centrum semiovale; Fig. 6). There was no stain in such lesions (Fig. 7).

Distribution of the lesion: There were bilaterally symmetrical destructions extending from the frontal to occipital lobes in the white matter (centrum semiovale; Fig. 8). Because of the severe destruction, the white matter could not be observed under the microscope.

The overall findings of the lesions throughout the five hanging suicide brains showed basically similar nature and distributions of the vascular lesions, although the severity and grading of the lesion differ from subject to subject (Figs. 1–8). The distribution of the vascular lesions mentioned above reminds us strongly of the venous origin, but not of the arterial origin.

Measured and calculated data of the cerebral pallium are given in Table 1. The brains did not show any alteration in volume or in corticomedullary volume ratio (CMVR).

Discussion

In the present study, five human brains of victims of suicide by hanging were examined by means of morphological and morphometric analyses. We found that the distribution of the cerebral lesions in those brains from the viewpoint of their location, spread and grading was different from the brains of people who had died of arterial infarctions. The overall findings of hanging suicide brains indicated a symmetrical presence of the lesions in the cerebral white matter (centrum semiovale) in both hemispheres extending in the fronto-occipital direction. These areas are in accord with the so-called "watershed" area of venous drainage between superficial and deep cerebral veins in the cerebral white matter: the typical case may be in AS-1344.

It is generally accepted that cerebral vessels have some special morphological characteristics: few variations for the extracranial trunks, abundant variations for the subarachnoid vessels and almost nonexistent variations for the intracerebral vessels. It is very important to understand these pathological findings in order to help victims of suicide by hanging or of accidental strangulation to recover and to provide effective means for rehabilitation.

The morphological features of the intracranial venous system are completely different from those of the intracranial arterial system. The intracranial venous system can be classified into three subsystems: the cerebral, brainstem-cerebellar and dural sinus systems. Furthermore, the cerebral venous system can itself be divided into two groups: the superficial and the deep cerebral venous systems. The superficial venous system gathers blood from the cerebral pallium (cerebral cortex and most of the subcortical white matter), while the deep venous system collects blood mainly from the upper half of the cerebral nuclei, part of the diencephalon and the deep zone of the cerebral white matter via the internal cerebral vein (Fig. 9), and partially from the lower half of the cerebral nuclei, part of the diencephalon and the mesencephalon via the basilar veins.

The present study shows the localization of the venous lesions to be between part of the superfi-
Hanging Suicide Brains

Fig. 9. Cerebral deep venous system drained by the ICV. CMV: cerebral medullary veins; CV: caudate vein; GCV: great cerebral vein; ICV: internal cerebral vein; SCV: subcallosal vein; SV: septal vein; TV: terminal vein.

The volumes of the cerebral cortex and cerebral medullary substance were calculated from block slices of brains using an image analyzer. The results show that the average brain weight (1,437 g in males and 1,185 g in females) did not differ much from the normal weight of Japanese brains (1,405 g in males and 1,268 g in females). Goto and Goto reported on four of the parameters to be used to evaluate the size of human brains: the volumes of the pallium, cortex, medullary substance and the CMVR. Morphometric evaluations of our present study did not reveal any significant conclusion due to the small number of subjects.

Hanging may cause compression of the cervical blood vessels resulting in cerebral hypoxia or even death. The above-mentioned pathological changes in the brain could be caused by interruption of the cerebral circulation leading to a rapid onset of neuronal damage due to hypoxia or ischemia. Generally speaking, certain areas of the brain seem to be more sensitive to hypoxia than others. For example, the cerebral cortex, basal ganglia and hippocampus may be included in the selective vulnerability areas, although all areas of the brain might suffer from hypoxia. However, our findings on the distribution of lesions in the hanging suicide brains are obviously different from the usual hypoxic brain lesions. Our results suggest that hanging may cause strangulation to the internal jugular vein and result in the brocking of the venous drainage from the brain before arterial obstruction or airway obstruction. This may give rise to a back pressure effect inside the cranium, especially in the brain. This phenomenon may cause a diffuse swelling and affect symmetrical low-density areas in the brain on both sides, as disclosed by CT examination. The present study revealed a similarity in the distribution of vascular lesions in the hanging suicide brains. Although the pathological findings may vary from case to case according to ligature methods, body weight, outside temperature and season, time elapsed after death, etc., we can classify the pathological grading into five stages in order of severity: (1) perivascular pallor (AS-1427, Fig. 1), (2) slight swelling (AS-1603, Fig. 3), (3) severe swelling (AS-1499, Fig. 4), (4) slight subcortical destruction (AS-1344, Fig. 6) and (5) severe subcortical destruction (AS-1479, Fig. 8).

Finally, we would like to emphasize the importance of understanding the changes in the brain structure after hanging, the cerebral blood flow, especially cerebral venous drainages, and the distributions of venous vascular lesions, in order to treat patients who have attempted suicide by hanging or to help in their rehabilitation.

Acknowledgments

We would like to thank Mr. M. Shibata for his technical assistance.

References


