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Surgical management of hematomas of the brain stem

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Nine patients with brain-stem hematoma were admitted to the authors' institute during the period from 1985 to 1988. Clinical symptoms and signs pointed to pontine involvement in most cases. Progressive clinical deterioration was quite common and usually led to a clinical diagnosis of brain-stem intra-axial tumor. Angiography was noncontributory; computerized tomography (CT) was the main diagnostic test. This gave evidence of different pathological characteristics, including masses showing highly increased density, nonhomogeneous hyperdense lesions, and isodense lesions with peripheral contrast enhancement. No clear correlation was found, however, between the presumed duration of the clinical picture and the CT characteristics of the lesion. In the last four cases, magnetic resonance imaging was performed using a 0.015-tesla resistive system. This examination usually confirmed the presence of a brain-stem mass already shown by previous CT scans. There were, however, no cases in which direct evidence of an intra-axial vascular malformation could be obtained. The patients were all treated surgically with an attempt at total removal of the lesion and thorough inspection of the hematoma cavity and biopsy. Evidence of "cryptic" arteriovenous malformation was obtained in six of the nine cases. There were minor transitory complications in three cases. All of the patients were able to resume their previous activity, and none suffered recurrence of the symptoms following the operation. It may be concluded that surgery is the treatment of choice for brain-stem hematoma.

KEY WORDS • **brain stem** • **hematoma** • **arteriovenous malformation** • **cryptic lesion**

INTRINSIC lesions in the brain stem represent a formidable challenge for neurosurgeons and in the past have usually been considered inoperable. Since the report in 1971 by Lassiter, *et al.*,[14] surgical treatment of intra-axial masses in the brain stem has been increasingly considered a realistic possibility, especially after the introduction of the ultrasonic aspirator and the refinement of diagnostic aids and microsurgical techniques.[9,10,16,26] The indications in favor of "radical" surgery for intra-axial brain-stem tumors are nevertheless still disputed.[12]

Brain-stem hematomas represent a pathological entity which at times very closely resembles intra-axial tumors, both from a clinical and a diagnostic point of view. These lesions are of great interest because they are potentially curable and because evidence is accumulating that surgical treatment is indicated. The definition of "brain-stem hematoma" obviously excludes massive primary pontine hypertensive hemorrhages,[11] which destroy the brain stem and are not realistically amenable to any form of treatment.[2,30] We report nine patients with brain-stem hematoma who underwent surgical treatment at the Institute of Neurosurgery "N.N. Burdenko" during the years 1985 to 1988.

Illustrative Cases

Case 1

This 4-year-old boy was admitted in February, 1989, with a 2-week history of vomiting, facial asymmetry, and left-sided gaze paresis. Examination showed a decreased corneal reflex on the left, a mild left sixth and seventh cranial nerve paresis, and horizontal nystagmus. There was mild left-sided incoordination. A computerized tomography (CT) scan showed a hyperdense homogeneous mass located within the brain stem, eccentrically situated and pushing the fourth ventricle slightly to the right (Fig. 1). These findings were confirmed by magnetic resonance (MR) imaging.

The lesion was approached through a midline incision. The hematoma was evacuated via a small incision in the floor of the fourth ventricle. Tiny pathological vessels were coagulated on the wall of the hematoma cavity. There was mild aggravation of the focal neurological symptoms which cleared within a week. The boy was discharged 15 days following surgery with minimal facial asymmetry and a very slight left-sided gaze paresis. These deficits appeared to be further improved at his 3-month follow-up examination.

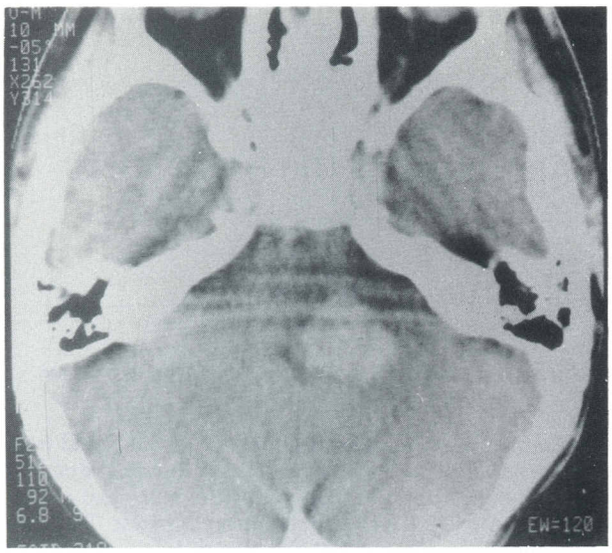

FIG. 1. Case 1. Computerized tomography scan shows an area of highly increased density located eccentrically into the brain stem. Note the deformed fourth ventricle.

Case 2

This 36-year-old woman came to our attention in March, 1988, with a 2-year history of headache, episodic vomiting and vertigo, and progressive weakness of the left upper and lower extremities. The weakness subsequently regressed, only to reappear 2 years later, together with left-sided facial weakness. Neurological examination disclosed left-sided facial hypesthesia, mild left-sided facial paresis, horizontal nystagmus, and mild left-sided incoordination. A CT scan showed a lesion of nonhomogeneously increased density at the level of the left cerebellopontine angle, extending toward the midline and displacing the fourth ventricle contralaterally. Magnetic resonance imaging showed a hyperintense lesion in the left cerebellopontine angle.

The lesion was exposed through a midline approach extended more on the left. The floor of the fourth ventricle was carefully incised over a discolored zone following negative exploration of the cerebellopontine angle. A biopsy of the hematoma wall showed findings consistent with a vascular malformation. The postoperative course was complicated by an increase in the severity of the patient's nystagmus and left-sided facial paresis. These eventually cleared within 6 months following operation.

Summary of Cases

Clinical Material

In the period covered by this study (1985 to 1988), nine cases of brain-stem hematoma were managed at the Institute of Neurosurgery "N.N. Burdenko." These included six females and three males, aged from 4 to 51 years (average 30 years). The duration of the clinical history varied from 1 month to 4 years. Significant remission of symptoms was reported by the five patients who had a clinical history lasting more than 6 months.

TABLE 1
*Clinical signs at admission**

Clinical Sign	No. of Cases
drowsiness	2
Parinaud's syndrome	2
hemiparesis	4
hemisensory deficit	4
cerebellar deficit	6
V nerve deficit	5†
VI nerve palsy	6
VII nerve deficit	8
nystagmus	5
VIII nerve palsy	6
IX & X nerve palsy	3

* Roman numerals denote cranial nerves.
† Three patients also had a trigeminal motor deficit.

Symptoms and Signs

A progressive clinical course was usually reported in this series. Headache was the most common presenting symptom, and acutely occurring pontine symptoms were reported in three cases. In these cases it was possible to make a clinical diagnosis of brain-stem hematoma. Headache and/or focal neurological symptoms were reported by all nine patients during the course of their illness. Seven patients complained of severe headache on admission without objective signs of increased intracranial pressure (ICP). Vertigo and ataxia were also common complaints (six cases). It is interesting to observe that three patients had subjective complaints of a periodic "sound in the head" without any correlation to the location of the lesion. Table 1 summarizes the clinical signs observed on admission. These were most often suggestive of pontine involvement.

Diagnostic Aids

Angiography (either vertebral artery injection or cerebral panangiography) was performed in four cases and produced evidence of nothing more than brain-stem enlargement. Computerized tomography was the main diagnostic tool in this series. The lesions produced different radiographic pictures, which may be summarized as follows: 1) a mass of homogeneously highly increased density (three cases, Fig. 1); 2) a round isodense mass with peripheral contrast enhancement (three cases, Fig. 2); and 3) a mass of nonhomogeneous increased density, with scattered areas of low attenuation and occasional calcifications and with irregular shapes (four cases, Fig. 3). We could not find any correlation between the duration of the clinical history and any particular CT finding. These masses deformed the fourth ventricle, which could, however, be identified in all cases, and they obliterated the cistern of the

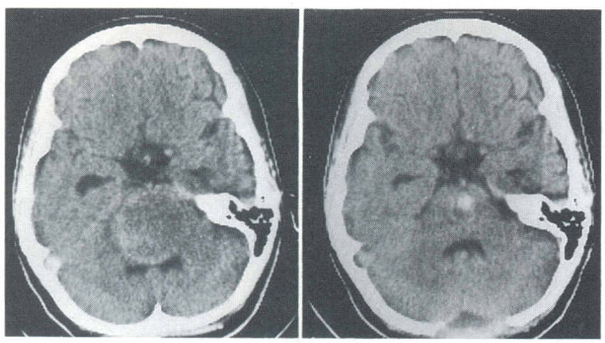

FIG. 2. *Left:* Preoperative computerized tomography (CT) scan with contrast enhancement. An isodense round, regular-shaped mass is seen intrinsic to the brain stem, with a fine ring of contrast enhancement. The fourth ventricle is partly obliterated due to bulging of the floor. *Right:* Postoperative CT scan without contrast enhancement obtained 7 days following surgery. The brain stem and fourth ventricle have resumed their normal shape. There is a small area of increased density within the hematoma cavity, which likely represents Oxycel packing filled with old blood clots.

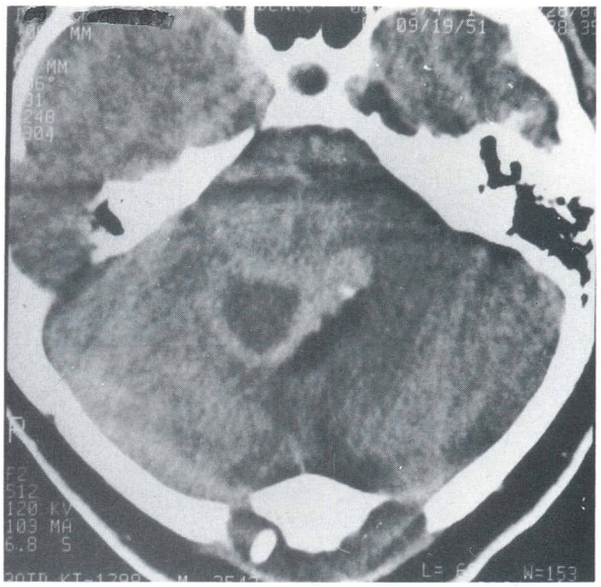

FIG. 3. Preoperative computerized tomography scan following administration of contrast medium showing a mass of nonhomogeneous increased density with high peripheral contrast enhancement. This mass involves the right half of the pons and obliterates the cerebellopontine angle cistern.

homolateral cerebellopontine angle when located laterally.

In the last four patients in the series, MR imaging was performed using a 0.015-tesla resistive system. This examination usually showed a hyperintense lesion in both T_1- and T_2-weighted images. In no case, however, could evidence of the presence of an underlying vascular malformation be found.

Surgical Treatment

All nine patients underwent surgery. In most cases the presumptive preoperative diagnosis was tumor of the brain stem. None of these patients was operated on as an emergency.

The patients were placed in the sitting position under continuous monitoring of brain-stem evoked potentials. The lesion was approached either through a paramedian incision in the floor of the fourth ventricle (six cases) or through a lateral pontine incision at the level of the cerebellopontine angle (three cases). Careful consideration of the preoperative CT and MR findings was essential for preoperative planning. The site of incision was chosen after careful observation of the brain-stem surface under strong magnification. A 2- to 3-mm linear incision was made with a microknife as low as possible at the level of the bulge (Fig. 4 *left*). This made it possible to obtain a good angle of visualization for thorough inspection of the hematoma cavity. After careful evacuation of the blood clots, the walls of the hematoma cavity were carefully inspected and abnormal blood vessels were coagulated, if necessary (four cases, Fig. 4 *right*); biopsy of suspicious portions of the hematoma wall was routinely performed and produced evidence of a "cryptic" arteriovenous malformation (AVM) in two more cases. An underlying vascular lesion was thus identified in six of these nine cases. Absolute hemostasis was achieved with fine bipolar cautery and was carefully checked by thorough saline irrigation.

Surgical Results

Only one patient had significant intraoperative or postoperative complications; in that case, bradycardia and vegetative disturbances did not permit removal of a minor portion of a sticky solid segment of the hematoma. This patient eventually recovered and is well 1 year after surgery. Rapid clinical improvement of the clinical symptoms was often observed, but three patients showed a worsening of their preoperative facial paresis following surgery. This deficit cleared in two cases within 1 year after the operation; the third patient showed some improvement of his almost total facial paralysis at his last follow-up examination 4 months after surgery. As a rule, routine postoperative CT showed disappearance of the mass effect at the level of the brain stem within 1 month (Fig. 2 *right*). All nine patients were discharged from the hospital within 2 weeks after surgery. The follow-up period ranged from 3 months to 3 years, and averaged $1\frac{1}{2}$ years. No recurrence of preoperative symptoms was observed, and all of the patients were able to resume their previous occupation.

Discussion

Incidence of Brain-Stem Hematoma

The reported incidence of hematoma of the brain stem varies from 7% to 16% of all intracerebral hema-

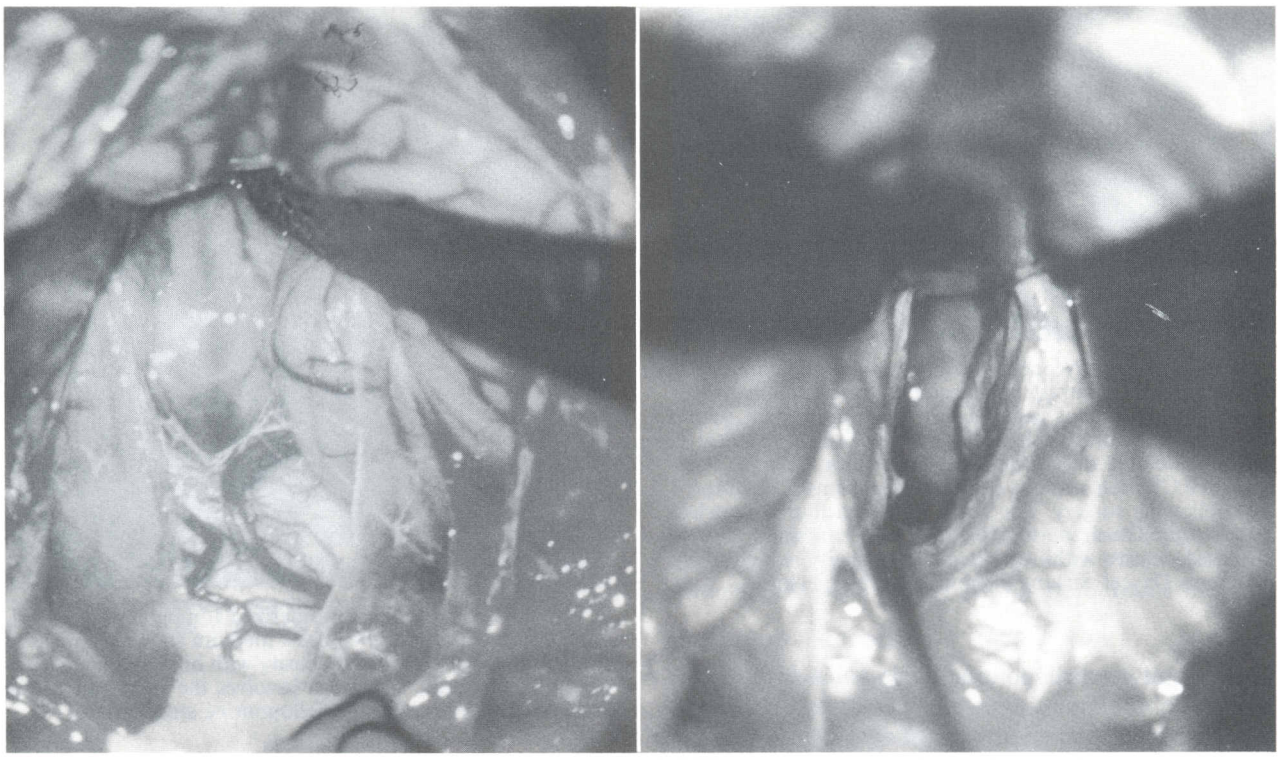

FIG. 4. *Left:* Intraoperative views under the operating microscope showing a discrete bulging of the floor of the fourth ventricle. *Right:* Following incision of the floor of the fourth ventricle, the hematoma was completely removed and abnormal vessels coagulated. The residual cavity is shown.

tomas.[2,7,11,29,30] But these figures include mostly intracerebral hematomas of hypertensive origin, which we have not considered in this study. Focal brain-stem hematomas usually occur in younger patients, possibly as a result of ruptures of so-called "cryptic" vascular malformations, either arteriovenous or venous;[27] however, pathological evidence of this is reported in only one-quarter of the cases described in the relevant literature.[16,17,29]

Hematomas are rare in this location: less than 90 such cases have been described.[16] McCormick and Nofzinger[18] reported that the pons represents the most common location of cryptic AVM's. A pontine location appears to be by far the most common site for brain-stem hematomas in our experience as well as in the available literature.[16] The patients in this series came to our institute under the clinical suspicion of brain-stem tumor. Although this is very common with brain-stem hematomas,[2,16,17,20,29,30] it may also be related to the fact that our institute is a large referral center with a particular interest in brain-stem intra-axial tumors. In the period covered by this study approximately 300 patients with brain-stem intra-axial tumors were admitted, 70 of whom were operated on in an attempt to effect a gross total removal (AN Konovalov: unpublished data). None of these cases of brain-stem hematoma was admitted acutely. Although this occurrence is rare,[2,16,30] we wonder whether it is related to the fact that the vast majority of our cerebrovascular cases do not come to us on an emergency basis.

Pathological Findings

Pathological evidence of a vascular malformation was obtained in six of these cases. This incidence is higher than that reported in previous literature reviews.[16,17] One generally accepted theory is that these malformations may be self-eliminating at the time of the hemorrhage,[15,21,29] which may explain why angiography is usually noncontributory, as in our cases. There may occasionally be evidence of some pathological changes other than those simply reflecting the presence of a brain-stem mass.[22]

Clinical Presentation

The average age of our patients (30 years) tallies with the data contained in the literature.[16] The clinical syndrome of brain-stem hematomas is protean and misleading, as it usually occurs with other lesions in this location. Brain-stem hematomas resemble tumors of the brain stem due to slowly progressing neurological deterioration or they may lead to an erroneous diagnosis of demyelinating disease due to relapses during a long-lasting clinical course.[28] A two-stage clinical course with ictal onset and subsequent progressive deterioration has

been described as a clinical feature peculiar to brain-stem hematomas.[2,30] This "peculiar" feature was reported by three of these nine patients, but is the exception rather than the rule. In a recent careful review of the literature,[16] one-quarter of the cases had a clinical course lasting more than 1 year, while another quarter received surgical attention within 15 days after the onest of symptoms. We observed a somewhat longer clinical course in our patients, which again could be related to our institute's referral policy.

Since the most frequently observed location of these hematomas was the pons, deficits of cerebellopontine angle nerves (often bilaterally) are the most commonly recorded clinical signs, together with pyramidal, hemisensory, and cerebellar deficits. Disturbances of consciousness and papilledema are rare. Parinand's syndrome, Horner's syndrome, and deficits of the 12th nerve are rarely reported due to the infrequent location of these lesions either caudal or rostral to the pons. In our cases we were unable to identify any especially particular clinical feature other than the presence of a severe headache without any objective signs of increased ICP. The subjective sensation of a "sound in the head," reported by three patients, was an interesting feature, but we were unable to find any correlation with this complaint and the location of the lesion and have no explanation for this phenomenon. Once again it must be stressed that in most cases the preoperative diagnosis was tumor of the brain stem.

Neuroradiographic Studies

Thorough neuroradiological investigations are mandatory if a possible preoperative diagnosis is to be achieved. As we have already pointed out, angiography is usually noncontributory. Some authors[15] have attributed this to arterial vasospasm. Computerized tomography is considered to be the main diagnostic tool in these cases. The characteristic CT features of these lesions include high density, well-defined borders, and an eccentric and/or paramedial location.[30] Brain-stem hematomas may also show areas of low attenuation in this context,[8,21] as well as a peripheral rim of contrast enhancement.[28] In one of our cases, calcifications were present. These features may lead to a preoperative diagnosis of brain-stem intra-axial tumors,[8] as in most of the cases in this series, and sometimes also of cerebellopontine angle tumors.[29] We did not find any clear correlation between the presumed duration of the clinical history and different CT findings, as is noted with intracerebral hematomas in other locations.[5,19]

Magnetic resonance imaging could be an extremely valuable tool for the correct preoperative identification of these lesions. In our experience, MR imaging usually confirmed the CT findings. We wonder whether, with more updated MR systems, a diagnosis of "cryptic" AVM underlying a brain-stem hematoma[22] or a diagnosis of an intra-axial tumor may be rendered with confidence preoperatively.

Surgical Management

In our opinion, intra-axial masses of the brain stem must be handled aggressively by attempted gross total removal whenever neuroradiological analysis suggests the existence of a cleavage plane between the lesion and normal tissue.[12] The fact that even today brain-stem hematomas can be mistakenly diagnosed preoperatively as brain-stem intra-axial tumors provides further support for this aggressive policy. There is broad agreement among authors[2,4,8,13,15–17,20,21,23,24] that surgery is the preferred treatment to apply to brain-stem hematoma. This opinion is supported by the recent extensive review of literature by Mangiardi and Epstein[16] who compared the results of surgical management of brain-stem hematomas to traditional methods.

In 66% of the present cases, there was evidence of a "cryptic" AVM. As we mentioned earlier, this incidence is strikingly higher than that reported in the literature,[8,17,21] and probably reflects our policy of carefully inspecting the hematoma cavity and searching for a possible vascular malformation. For this procedure, the surgical field must be sufficiently wide to allow for meticulous and careful inspection of the brain-stem surface prior to performing an incision, however limited this is. A midline approach was preferred in most cases, and the lateral approach through the cerebellopontine angle was chosen in cases where location of the lesion was strictly unilateral and the hematoma, as shown by preoperative neuroradiological investigations, had almost reached the lateral pontine surface. We attempted to perform the brain-stem incision as low as possible, in order to achieve the best visual angle for careful inspection of the hematoma cavity. With this approach the liquefied clots came out easily but some dissection was usually required in order to remove the solid portion of the hematoma. In one case, total removal of the clot could not be performed, but the patient recovered and was well at follow-up examination 1 year after surgery. However, in such cases the presence of a vascular malformation or the possibility of late postoperative rebleeding cannot be excluded.

Some authors recommend less aggressive surgical policies in the approach to these lesions, such as evacuation by means of puncturing the exposed brain stem[21] or stereotactic evacuation.[3,6] The reported results of those treatments appeared to be satisfactory, although the patients' follow-up period was admittedly brief. In our opinion, these techniques only permit management of the liquefied portion of the hematoma (which in some cases is small compared to the solid portion) and usually do not allow the identification and subsequent eradication of the vascular malformation causing it. As has already been pointed out in the literature,[16,25] rebleeding may represent a serious problem for these patients, who are usually young, when the underlying vascular malformation is left untreated.[1]

Whatever the technical principle and surgical policy selected, it must be stressed that the results of surgical

treatment are usually gratifying. In the cases presented here there was a rapid improvement following surgery, although in three cases a transitory worsening of certain symptoms did occur. There were no instances of postoperative worsening due to rebleeding of a vascular malformation missed during surgery. This confirms our policy of careful inspection of the hematoma cavity under high magnification and biopsy of suspicious portions of the wall.

In conclusion, brain-stem hematomas represent a clinical entity requiring careful clinical and neuroradiological attention, and are of great interest to the neurosurgeon because they are potentially curable. To this end, accurate preoperative planning of the surgical approach and a meticulous surgical technique are mandatory.

Addendum

Following submission of this paper for publication, six additional cases of brain-stem hematoma have been admitted and operated on successfully in our institution.

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Address reprint requests to: Aldo Spallone, M.D., 2nd University of Rome, "Tor Vergata" Via Orazio Raimondo, 00173 Rome, Italy.