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Neurinomas of the first two cervical nerve roots: a series of 42 cases

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A group of 42 patients with C-1 and C-2 neurinomas treated during the 10-year period 1982 to 1992 has been collected, including 25 cases from 20 French neurosurgical departments and 17 personal cases from the Neurosurgical Department of the Lariboisière University Hospital, Paris. Analysis of this series reveals some interesting findings relating to multiplicity of tumors, extradural extension, and neurofibromatosis.

There were seven patients with multiple lesions (bilateral C-2 neurinomas in six cases and two neurinomas at C-2 and one at C-1 in one case). In the 35 other cases, 16 lesions were entirely extradural and 19 had an hourglass configuration. Thirteen patients presented signs of neurofibromatosis. One lesion had a melanotic form and another was a radiation-induced schwannoma.

Surgical results were excellent in most cases with no immediate postoperative death. Best results in terms of complete removal and neurological condition were achieved with posterolateral or anterolateral surgical approaches (17 cases) as compared with the standard midline posterior route (25 cases).

KEY WORDS • neurinoma • foramen magnum • neurofibromatosis • hourglass tumor • lateral approach

NEURINOMAS of the first two cervical nerve roots are rare. They represent approximately 5% of all spinal neurinomas and 18% of the cervical localizations in the few published series. Neurinomas of the C-1 and C-2 nerves are generally included in series of spinal neurinomas[3,4,7,8,16,18,19,24,26] or of foramen magnum tumors.[1,6,7,13–15,17,21,25,28,29] They are very rarely described in separate studies.[9] However, they exhibit specific features, such as multiplicity, hourglass formation, and relationship with the vertebral artery (VA) that cause particular surgical problems.

This report deals with a series of 42 cases observed over a 10-year period. In 17 cases, the lateral surgical approach was used, with VA control.

Clinical Material and Methods

Patient Population

The series included 25 cases from 20 French neurosurgical departments (Amiens, Angers, Clermont-Ferrand, Colmar, Grenoble, Lille, Limoges, Lyon, Marseille, Nancy, Orléans, Paris Beaujon, Paris Bicètre, Paris Foch, Paris Henri Mondor, Paris La Pitié, Rennes, Toulouse Rangueil, Toulouse Purpan, and Tours) and 17 personal cases treated at the Lariboisière University Hospital. A total of 42 cases was treated during the 10 years between 1982 and 1992. The analysis was done from clinical, radiological, surgical, and postoperative information obtained directly from complete patient records, either sent to us or examined in the treating departments with the neurosurgeons in charge of the patients. All the collected data were computerized for analysis.

Clinical Data

There were 21 women and 21 men, aged from 18 to 80 years old (average 45.6 years). The delay between the first symptom and diagnosis ranged from 3 months to 12 years (average 26.8 months). The first symptom was most frequently motor deficit, posterior headaches, a variable degree of neck stiffness, or paresthesiae in one or both hands (Table 1). At the time of diagnosis, a motor deficit was observed in 83%, a sensory deficit in 60%, and sphincter disturbances in 19%. Posterior headaches were mentioned by 31% of the patients, increasing during head movements for 8% of them. Some stiffness in the neck was present in 17% and Lhermitte's sign in 5% (Table 1).

The patients were clinically evaluated following a grading system derived from that proposed by Yaşargil, *et al.*,[27] for posterior fossa meningiomas, as follows: Grade 0, no symptoms; Grade 1, one minor symptom; Grade 2,

minor symptoms or signs; Grade 3, marked symptoms and signs; Grade 4, bedridden. For postoperative evaluation, we have added Grade 5, denoting death. This system is quite reliable if the symptoms are not underestimated, especially for Grade 1 which must only include a minor symptom. Marked motor deficit or severe swallowing disturbances, even if they occur alone, lead to a classification of Grade 3. This grading system was applied as a single variable to each patient and permits comparison of the pre- and postoperative clinical condition; improvement is defined as a lower postoperative than preoperative grade and worsening as a higher postoperative grade.

We then used an index of severity (IS) $\pm$ standard deviation, devised at our institution, to define different categories of patients based on the mean value of the patients' grades. The IS allowed for comparison within the different groups of patients: 1) patients with neurofibromatosis, schwannomas, and neurofibromas; 2) patients with C-1, C-2, and bilateral neurinomas; 3) patients with intradural, extradural, and hourglass-shaped neurinomas; and 4) patients treated by the midline posterior approach and by the lateral approaches. Statistical analysis was done in each group between the pre- and postoperative IS of the different categories of patients. The Student t-test was used to compare two patient categories and the Fisher F test with analysis of variance (ANOVA) was used for more than two categories. The preoperative IS and grade distribution are correlated in Table 2 for the two categories of schwannomas and neurofibromas and for the whole series. The preoperative IS was 2.48 ± 0.13 for the entire study group. Table 3 presents the pre- and postoperative IS for the patients in the four groups indicated above.

In this series, 12 patients exhibited signs of neurofibromatosis type 1 (von Recklinghausen's disease) and one had evidence of neurofibromatosis type 2. The mean age of this group with neurofibromatosis was 32 years and there were four women and eight men. The mean delay before diagnosis for this group was 16 months. The clinical signs and presentation were similar in this group to those shown by all the other patients, with an IS of 2.54 ± 0.18.

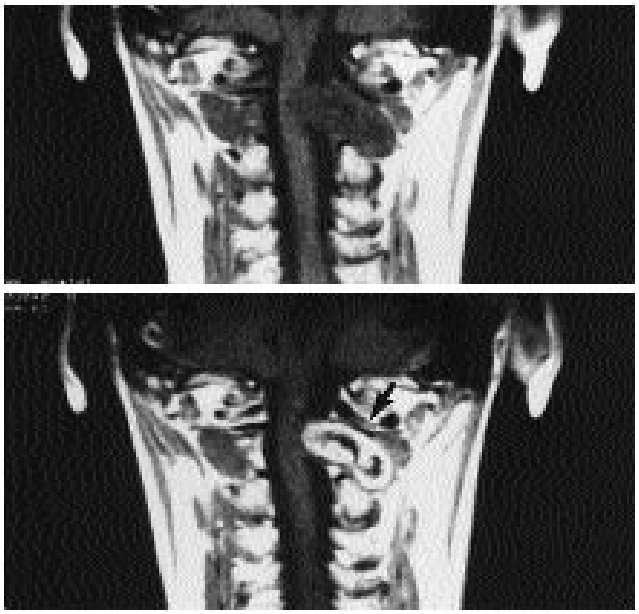

FIG. 1. Magnetic resonance images showing an extraintradural neurinoma of the C-2 nerve root before *(upper)* and after *(lower)* gadolinium injection. Notice the relation with the vertebral artery *(arrow)*.

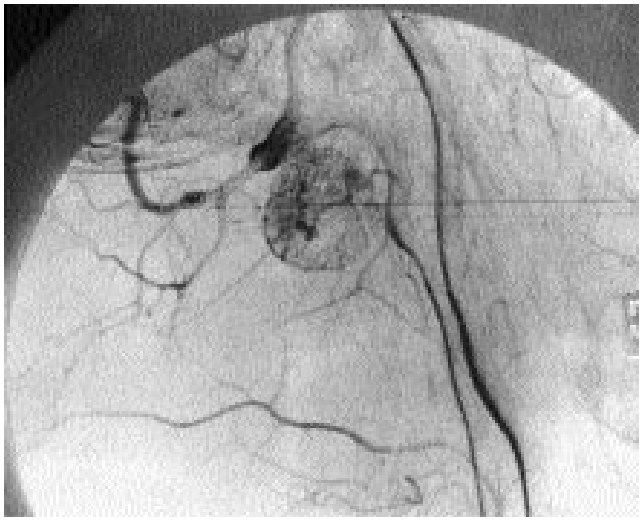

FIG. 2. Angiogram revealing a neurinoma of the C-2 nerve root with tumoral injection from a vertebral artery branch at C-2.

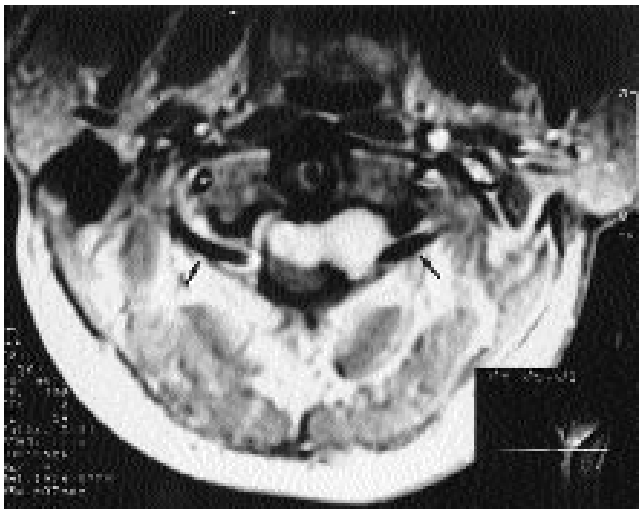

FIG. 3. Postgadolinium magnetic resonance image showing an extraintradural neurinoma of the C-1 nerve root. The connection with the vertebral artery is shown *(arrows)*.

Radiological Data

Diagnosis was made on computerized tomography (CT) scans and magnetic resonance (MR) imaging in all cases. Contrast enhancement of the tumor was observed in 15 CT scans and nine MR images (Fig. 1). Angiography was performed in 32 cases, and moderate tumor opacification was noted in 19 cases, with the feeding branches arising from the VA at C-3 in five cases, C-2 in 14, and C-1 in five (Fig. 2). The VA was in contact with the tumor in 23 cases, as estimated from the CT scans and/or MR images (Figs. 1 and 3). Angiography showed the VA to be shifted by the tumor in 16 cases and compressed with some stenosis in three cases. During surgery, association with the VA was confirmed in 20 instances.

Tumor Location

The location of the lesion was determined following the classification system we have proposed for extramedullary foramen magnum tumors,[10] which is based on the structure to which the tumor is attached. Anterior lesions are located on both sides of the midline, lateral ones between the midline and the dentate ligament, and posterior ones behind the dentate ligament. Therefore, C-1 and C-2 neurinomas, like any other neurinoma, are classified as lateral whatever anterior or posterior extension they may have.

This series included 35 single neurinomas (30 at C-2 and five at C-1) and seven multiple neurinomas (Fig. 4). All seven multiple cases consisted of bilateral C-2 neurinomas, associated in one case with a C-1 neurinoma, for a total of 50 C-1 and C-2 neurinomas among 42 patients. One lesion was classified as a C-1 neurinoma because of its location, although no connection could be identified with any nerve root.

Only seven neurinomas were strictly located intradurally, five on the C-2 and two on the C-1 nerve root. Sixteen lesions were exclusively extradural (Figs. 4 and 5) and 19 with an hourglass configuration had both an intra- and extradural extension (Figs. 1 and 3). A location on the anterior or posterior rootlets could be clearly determined only for the five intradural C-2 neurinomas, all of which seemed to arise from the posterior rootlets.

The group with neurofibromatosis included only neurinomas with extradural (seven cases) or hourglass (six cases) extension. All of the multiple cases belong to this group.

Surgical Data

The surgical approaches used included the posterior, posterolateral, and anterolateral approaches (Fig. 6), either alone or in combination (Table 4). They are summarized only briefly because they have already been described elsewhere.[10–12] The posterior approach is a standard midline posterior opening with laminectomy of C-1

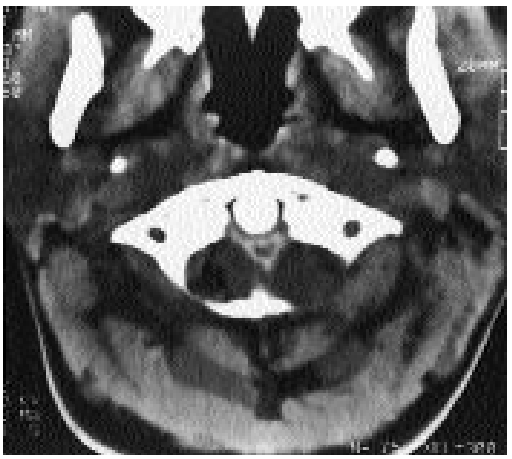

FIG. 4. Computerized tomography scan after metrizamide myelography showing extradural bilateral neurofibromas of the C-2 nerve root.

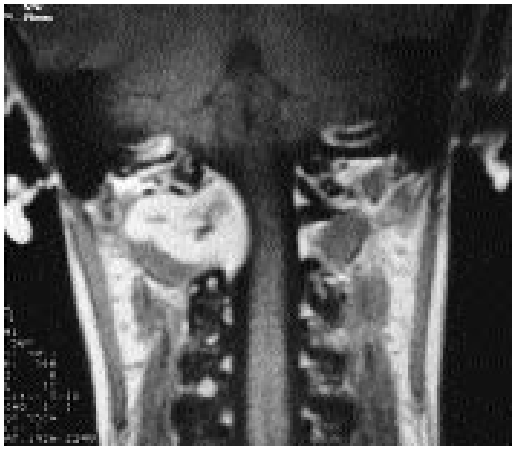

FIG. 5. Postgadolinium magnetic resonance image showing a unilateral extradural neurofibroma of the C-1 nerve root.

and C-2 for the C-2 neurinomas, and with resection of the posterior arch of the atlas and of the inferior part of the occipital bone for the C-1 neurinomas. The posterolateral approach[10,12] is a standard posterior approach enlarged laterally up to the transverse foramen of C-1 to include exposure of the VA above C-1 and between C-1 and C-2. The anterolateral approach is designed to expose the cervical part of the VA.[11] It passes between the sternomastoid muscle and the internal jugular vein. The spinal accessory nerve is dissected free and the transverse process of C-1 is exposed. Then the VA is controlled either in the groove above the posterior arch of C-1 for C-1 neurinomas or between C-1 and C-2 for C-2 neurinomas. The posterior arch of C-1 and occasionally of C-2 is opened accordingly.

Whatever the type of lateral approach, the VA must be controlled extraperiosteally to avoid troublesome bleeding from the venous plexus that lies inside the periosteal sheath surrounding the artery. The C-1 nerve root is always difficult to identify in its extradural and extraspinal portion because it is a very thin strand emerging between the VA and the groove of the atlas. In contrast, the C-2 nerve root is easily exposed as it separates into anterior and posterior branches while curving around the VA and it has a long course between the dural sac and the VA. Therefore, it is always possible to control the C-2 nerve root distal to the neurinoma. The C-2 nerve root was always entirely involved in cases of neurinoma with an extradural component, so it must be divided at the level of its main trunk or sometimes more distally at the level of its two branches. Division of the C-1 nerve root does not produce any appreciable sensory deficit. If the C-1 nerve root is cut intradurally, care must be taken to preserve the medullary root of the accessory nerve, which was always possible in our series. Because of important distal anastomoses, division of the proximal segment of the C-2 nerve root generally produces only a very mild sensory deficit, if any, and then in a very limited area. However, distal branches were always divided either subcutaneously with the anterolateral approach or in the posterior muscles with

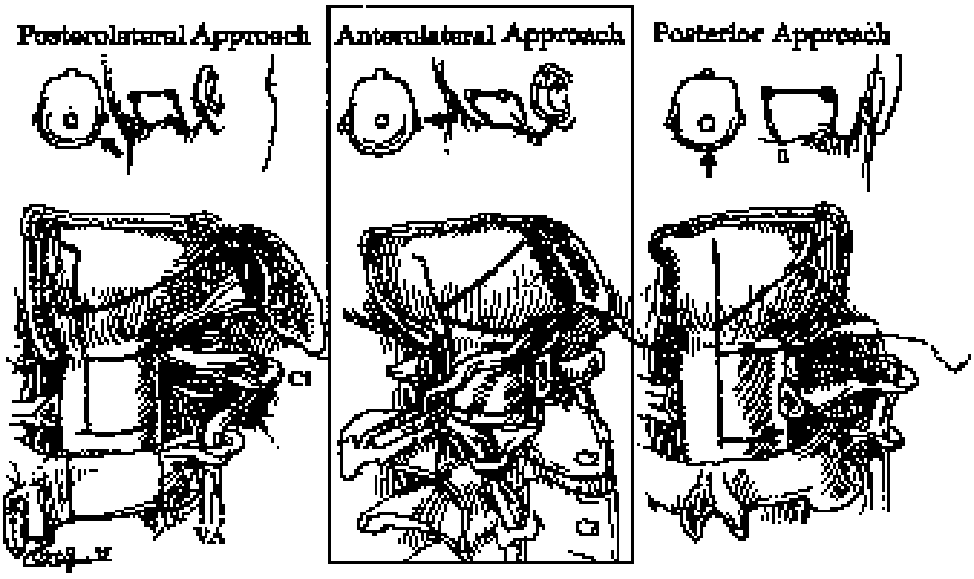

FIG. 6. The three surgical approaches utilized for neurinomas of the C-1 and C-2 nerve roots. Dural incisions are indicated by *dotted lines*, and the respective bone removal is shown. The direction of approach is indicated by *arrows*, above. VA = vertebral artery.

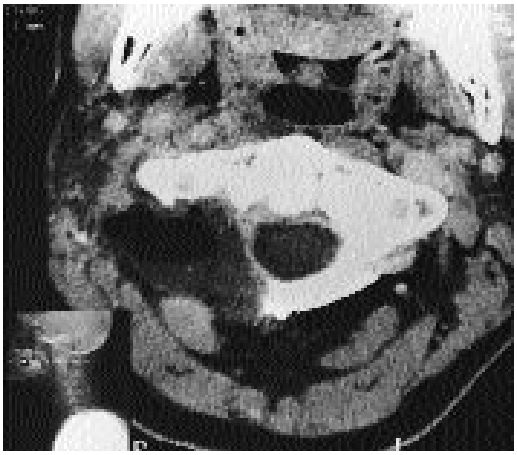

FIG. 7. Postoperative computerized tomography scan at the C-1 level showing the extent of the bone opening with partial resection of the C-1 lateral mass. This is the same patient as depicted in Fig. 5, treated with complete resection through an anterolateral approach.

the posterolateral approach. This leads to hypesthesia or dysesthesia in the corresponding territory: the ear lobe and angle of the jaw for the former and the posterior region of the head for the latter.

Total resection was achieved in 37 cases (Fig. 7), subtotal in three, and partial in two. Subtotal resection is defined as a removal leaving a remnant less than 5 mm in length, generally close to the VA. Partial resection denotes that a portion of tumor more than 5 mm in length was left. Of our 17 personal cases, resection was total in all but one, a melanotic schwannoma invading the pial covering of the medulla oblongata.

Histological Data

Most tumors in this series were schwannomas (27 cases). One of these was a melanotic form of schwannoma. Neurofibroma was the pathological finding in the 15 other patients including 12 cases of neurofibromatosis type 1. These 12 patients had the familial history and cutaneous signs of von Recklinghausen's disease. When other tumors were associated, their appearance was always that of a neurinoma. Three patients with neurofibroma exhibited no signs of neurofibromatosis. One patient with neurofibromatosis had a schwannoma of C-2 associated with an acoustic neurinoma and a temporal meningioma.

Results

With a follow-up period ranging from 1 to 10 years, only two patients in this series died. One was a woman of 73 years who presented with tetraparesis which led to the discovery of an hourglass neurinoma of C-2. The tumor was partially removed, followed by a marked improvement of her neurological condition. However, the tumor recurred 14 months later, with progressive onset of tetraplegia leading eventually to death. Reoperation was contraindicated because of the patient's poor general and cardiac condition. The other patient was a 39-year-old man treated 11 years before by radiotherapy directed to the cervical area for Hodgkin's disease. He then presented an hourglass neurinoma of C-2, which was completely removed in two stages by a combination of anterolateral and posterior approaches. Pathological examination revealed a schwannoma without any malignant features. The tumor recurred 1 year later as a very invasive process, which proved to be a sarcoma and led to death in the following months.

There were no immediate postoperative deaths. Two patients suffered neurological worsening, related to air embolism after surgery in the sitting position. The 38 other patients improved markedly.

The IS distribution, comparing the pre- and postoperative status, is given in Table 3 for the whole series and for all groups of patients. There is no statistical difference in the preoperative IS between the different categories of patient in each group. For instance, the preoperative IS data of schwannomas and neurofibromas or of intradural, extradural, and hourglass neurinomas are similar. Postoperatively, the IS data of intradural and hourglass neurinomas are statistically different and higher than the IS of extradural neurinomas ($p < 0.05$). The postoperative IS data of C-1, C-2, and bilateral neurinomas are not statistically different. For schwannomas and neurofibromas, only the variances are statistically different ($p < 0.01$). For patients treated by the posterior approach and those treated by the lateral approach, the preoperative IS data are not statistically significantly different nor are their variances. For the postoperative IS, only the ANOVA shows a statistically significant difference ($p < 0.001$), indicating similar but more homogeneous results with the lateral approach than with the posterior approach.

The postoperative IS for the entire study group was 0.71 (Table 3). The patients with neurofibromatosis improved their IS from 2.54 preoperatively to 0.54 postoperatively, whereas the IS of patients with schwannomas changed from 2.48 to 0.85. The postoperative IS of the C-1, C-2, and bilateral neurinomas was, respectively, 0.60, 0.80, and 0.43. Operative results are given in Table 5 according to surgical techniques. The posterolateral and anterolateral approaches provided better results than the posterior technique in terms of improvement of the clinical condition and rate of complete resection in this study.

Discussion

Reports on neurinomas of the C-1 and C-2 nerve roots are scarce. They are generally included in series of cervical or spinal neurinomas[3,4,7,8,9,16,18,19,24,26] or in series of

foramen magnum tumors.[1,6,7,13–15,17,21,25,28,29] According to these publications, C-1 and C-2 neurinomas account for 5.3% of all spinal neurinomas, 18% of all cervical neurinomas, and 34% of foramen magnum tumors excluding osseous tumors. The present 42 cases were among 230 cases of foramen magnum tumors including 176 nonosseous tumors.[12] Hence, these C-1 and C-2 neurinomas accounted for 18% of the total foramen magnum tumors and 24% of nonosseous tumors in our series.

Location on the C-2 nerve root is much more common than on C-1; Yasuoka, *et al*.,[28] reported 18 tumors on C-2 and one on C-1, and Guidetti and Spallone[13] described six on C-2 and three on C-1. Our series included six C-1 neurinomas and 44 C-2 neurinomas in 42 cases, with seven multiple cases (six with bilateral C-2 neurinomas and one with a C-1 tumor plus bilateral C-2 neurinomas). One case was classified as having a C-1 location because of its level but no clear contact with any rootlet could be demonstrated. The tumor was a melanotic intradural schwannoma adherent to the surface of the spinal cord. Bollati, *et al*.,[2] also reported a schwannoma without association with any root but which developed inside the dura at the C-1 level.

Multiplicity is a particular feature of these neurinomas. The rate of multiple neurinomas at any level in the spine can be estimated at 4%. In our series, it is as high as 17%. This fact is obviously related to the high incidence of neurofibromatosis. Thirteen (31%) of our patients presented signs of neurofibromatosis type 1 or 2. Three other cases were diagnosed as having neurofibroma but without any familial or personal features of neurofibromatosis.

One of the tumors in our series was probably induced by radiation and was identified as a sarcoma when it recurred 1 year after resection. Two cases of radiation-induced neurinoma of C-2 were reported by Rubinstein, *et al*.[23] There are also two cases of neurofibrosarcoma with evidence of von Recklinghausen's disease in the literature.[6,22] Our case was not a neurofibromatosis but a single schwannoma, which developed 11 years after radiation therapy for Hodgkin's disease.

The histological diagnosis of our cases included, besides the radiation-induced sarcoma and the 15 cases of neurofibroma, one melanotic schwannoma. This case was located at the level of the C-1 nerve root and was removed only subtotally because of invasion of the pial covering of the spinal cord and medulla oblongata. Histological examination showed no sign of malignancy and therefore no adjuvant treatment was proposed. With 2 years of follow-up monitoring, there has been no sign of recurrence. In the literature, we were able to find only one case of melanotic neurinoma at this level.[20]

Symptoms of C-1 and C-2 neurinomas suggest a high cervical cord compression. There is no distinction between them and symptoms of neurinomas at other locations. However, Chalif, *et al*.,[5] reported finding a C-2 intradural neurinoma in a 56-year-old woman who suffered a subarachnoid hemorrhage. Comparison of the mean IS of neurinomas with that of meningiomas of the foramen magnum shows a very similar neurological condition at diagnosis. In our series of 230 cases, the mean preoperative IS was 2.48 for neurinomas and 2.39 for meningiomas.[12]

Patient age at diagnosis of C-1 and C-2 neurinomas is similar to that of other locations in the spine. Two patients in our series and six in the literature were under 20 years old. Among these cases, seven had von Recklinghausen's disease. The mean delay before diagnosis (28 months) is no different from that with other localizations of neurinomas in the spine.

Involvement of the dura mater is quite uncommon among spinal neurinomas. Thirty-five of our cases (83%) had an extradural extension, including 19 cases with an hourglass configuration and 16 entirely extradural cases. In series of spinal neurinomas, the percentage of extradural or hourglass formation is much lower: namely, 16%. This feature is important to consider on choosing the surgical technique, because an extradural extension requires a lateral opening for proper removal.

Another important point in selecting the surgical technique is the relationship of the lesion with the VA. This relationship could be demonstrated in 23 cases by CT or MR imaging and was confirmed by angiography, which showed displacement of the VA in 16 cases and stenosis in three cases. With a likely diagnosis of neurinoma, angiography is certainly not necessary. A complete and precise MR image with an angiographic MR study is sufficient to give the information necessary to appreciate the relationship with the VA and to choose the appropriate surgical technique.

The surgical technique was either a standard posterior, an anterolateral, or a posterolateral approach (Fig. 6). The two last techniques were used in most cases in which an extradural extension and a connection with the VA had been demonstrated on preoperative imaging. These techniques, enlarging the usual opening laterally, provide the best results in terms of either rate of complete resection or clinical improvement. This fact has also been demonstrated for other types of tumor of the foramen magnum and particularly for meningiomas.[10,12,22] With regard to C-1 and C-2 neurinomas, these techniques permit access to any tumoral extension and especially the extradural component close to the vertebral artery. This advantage of the lateral approach has already been demonstrated in lower cervical neurinomas.[10] Moreover, lateral approaches give a lateral access to the intradural portion, avoiding any manipulation on the spinal cord and medulla, and any traction on the tumor when it extends anteriorly. This is the most likely explanation of the better clinical results obtained with these techniques than with the standard posterior approach. Similar good results are obtained whether the neurinoma is located on the C-1 or C-2 nerve root. Following localization, extradural neurinomas have better results than intradural or hourglass neurinomas. This explains why bilateral neurinomas, which are most often extradural, have similarly excellent results. It also explains why patients with neurofibromatosis enjoy as good results as the rest of the series because, in nine of the 15 cases, the neurofibromas are entirely extradural. The connection between neurinomas with an extradural component and the VA has never caused a problem. With the lateral techniques, which always include control of the VA, the plane between the VA and the tumor capsule was always easy to follow even in cases of VA compression or stenosis.

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TABLE 1

Initial signs and symptoms in 42 patients

Signs & Symptoms	No. of Cases
signs	
posterior headache	11
neck stiffness	2
motor deficit	14
paresthesia	6
radiculalgia	2
neck swelling	3
gait disturbances	2
symptoms	
motor deficit	35
sensory deficit	25
posterior headache	13
sphincter disturbances	8
neck stiffness	7
Lhermitte's sign	2

TABLE 2

Preoperative grading and index of severity (IS)

Tumor Histology	Preop Clinical Grade					Preop IS
	0	1	2	3	4	
schwannoma	0	3	12	8	4	2.48
neurofibroma	0	1	7	6	1	2.47
total	0	4	19	14	5	2.48

TABLE 3

Pre- and postoperative index of severity (IS) correlated with various clinical factors

Factor	Preop IS	Postop IS
histology of lesion		
whole series	2.48 ± 0.13	0.71 ± 0.16
schwannoma	2.48 ± 0.17	0.85 ± 0.24
neurofibroma	2.47 ± 0.19	0.47 ± 0.13
neurofibromatosis	2.54 ± 0.18	0.54 ± 0.14
nerve roots affected		
C-1	2.20 ± 0.58	0.60 ± 0.40
C-2	2.43 ± 0.14	0.80 ± 0.21
bilateral	2.86 ± 0.26	0.43 ± 0.20
location of neurinoma		
intradural	2.86 ± 0.34	1.29 ± 0.52
extradural	2.25 ± 0.25	0.25 ± 0.11
hourglass	2.53 ± 0.14	0.89 ± 0.26
surgical approach		
midline posterior	2.48 ± 0.15	0.84 ± 0.26
lateral (posterior or anterior)	2.47 ± 0.23	0.53 ± 0.13

TABLE 4

Surgical approaches and location of the tumor

Surgical Approaches	Tumor Location*			Total Cases
	ID	ED	ID–ED	
posterior	5	9	11	25
posterolateral	2	3	6	11
anterolateral	0	4	1	5
posterior & anterolateral	0	0	1	1

* ID = intradural; ED = extradural.

TABLE 5

*Results correlated with surgical approaches**

Result	Posterior Approach	Postlat or Antelat Approach
mean postop IS	0.84	0.53
% with good result	92%	100%
% with improvement	88%	100%
% with complete removal	84%	94%

* IS = index of severity; good result = Grades 0, 1, and 2 (see text for definition); improvement = better postoperative than preoperative grade; postlat = posterolateral; antelat = anterolateral.