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COMPARISON OF MRI-GUIDED AND VENTRICULOGRAPHY-BASED STEREOTACTIC SURGERY FOR PARKINSON'S DISEASE

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ABSTRACT - Stereotactic surgery for Parkinson's disease can be performed using different neuroimaging methods. Ventriculography has been used to locate the coordinates of the structures close to the third ventricle. Although it has several potential disadvantages related to the intraventricular injection of iodine contrast, it is considered a precise method. Computed tomography and magnetic resonance imaging have been used in some centers. In order to compare their efficacy, 50 stereotactic thalamotomies for Parkinson's disease were performed using either ventriculography (VE) (25) or magnetic resonance imaging (MRI) (25). In 14 out of 25 VE procedures, computed tomography (CT-scan) was also used and showed a significant mean difference of coordinate Y and Z. The clinical results employing either VE or MRI were similar; with 80% abolition of tremor in the VE group, and 84% in the MRI group, after a follow up period of at least 3 months. Another 12% of VE and 16% of MRI group showed significant improvement of tremor. Complication rate was 4% in both groups. MRI-guided stereotactic thalamotomy in Parkinson's disease has shown good clinical results, comparable to VE-guided stereotaxis.

KEY WORDS: stereotactic thalamotomy, Parkinson's disease, ventriculography, magnetic resonance imaging.

Estudo comparativo de cirurgia estereotáxica guiada por ressonância magnética e ventriculografia para doença de Parkinson

RESUMO - A cirurgia estereotáxica para doença de Parkinson (DP) pode ser realizada com diferentes métodos de neuroimagem. A ventriculografia (VE) tem sido empregada para determinar as coordenadas estereotáxicas das estruturas próximas ao terceiro ventrículo. Apesar de várias desvantagens relacionadas com a injeção intraventricular de contraste iodado, é considerada como uma técnica precisa. A tomografia computadorizada (TC) e a ressonância magnética (RM) têm sido utilizadas em alguns centros. Para comparar a eficácia dos diferentes métodos, 50 talamotomias estereotáxicas para DP foram realizadas utilizando VE (25 casos) e RM (25 casos). Em 14, dos 25 casos com VE, o emprego concomitante de TC demonstrou diferença média importante nas coordenadas Y e Z. Os resultados clínicos utilizando-se VE ou RM foram similares, com 80% de abolição de tremor no grupo com VE e 84% com RM durante seguimento mínimo de 3 meses. Além disso, 12% do grupo com VE e 16% do grupo com RM apresentaram significativa melhora do tremor. Índice de 4% de complicações foi encontrado em ambos os grupos. Não houve mortalidade. A talamotomia estereotáxica guiada por RM para DP demonstrou resultados comparáveis aos obtidos com VE.

PALAVRAS-CHAVE: talamotomia estereotáxica, doença de Parkinson, ventriculografia, ressonância magnética.

Stereotactic surgery has been used in selected patients with Parkinson's disease for relieve of tremor, rigidity, and bradykinesia with good results[5,8,18,23,29]. Different imaging techniques have been used to determinate the anatomical target. Electrophysiological tests help to confirm the right site to be coagulated. Ventriculography has been utilized to locate the coordinates of the structures located close to the third ventricle, such as anterior and posterior commissures and the lateral wall of the third ventricle. It is considered a precise method, although it has several potential disadvantages related to the intraventricular injection of air[10] or iodide contrast[16,22]. Computed tomography (CT-scan) has been used in some centers[2,9,16,19], in spite of some limitations of the method. Magnetic

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resonance imaging (MRI) yields multiplanar images, presents a higher contrast resolution, and allows direct visualization of the intracranial structures, in special the internal capsule and basal ganglia[21,26].

We present a series of 50 stereotactic thalamotomies in 43 patients with Parkinson's disease using either ventriculography or MRI.

PATIENTS AND METHODS

Fifty stereotactic thalamotomies out of 98 performed in three years were analyzed. The procedures were done in 43 patients with severe Parkinson's disease refractory to conventional medical treatment. A total number of 23 right thalamotomies, 17 left thalamotomies, 5 bilateral thalamotomies were performed. Two patients underwent right thalamotomy twice. The reason for a second intervention in those cases was the relapse of symptomatology within 3 months of follow-up. A minimum three month-interval between procedures was adopted in another 5 patients, who underwent bilateral thalamotomy. Thirty-two patients were males and 11 females.

Ventriculography (VE) was used in 25 procedures. CT-scan (General Electric Sytec 3000) was concomitantly performed with ventriculography in 14 procedures. The purpose was to compare both methods. Ventriculography was considered the gold standard. MRI was used in the other 25 procedures (General Electric MR Max 0.5 T). Under local anesthesia, an ET 018 (692) (Micromar, São Paulo) Hitchcock modified stereotactic frame was attached to three or four points in all patients. This frame is MRI compatible. The sagittal reference consists of 9 fiducial marks. For the localization in the axial plane we used bilateral, anterior and posterior N-shaped fiducial devices.

The calculation of the target to perform thalamotomy is described elsewhere[14]. Briefly, the coordinate X is taken 11.5 mm lateral from the third ventricle lateral wall. The coordinates Y and Z are located 2 mm posterior and 2.5 mm superior from the midpoint of the intercommissural line. Anterior and posterior commissures and the lateral wall of the third ventricle were identified by different imaging methods (VE, CT-scan, or MRI). CT scan axial slices allowed determination of these anatomical landmarks. Hence MRI sagittal images gave direct view of the anterior and posterior commissures (Fig 1), while coronal and axial slices showed the third ventricle boundaries. Deep cerebral structures, e.g. basal ganglia, internal capsule, and thalamus were also recognized.

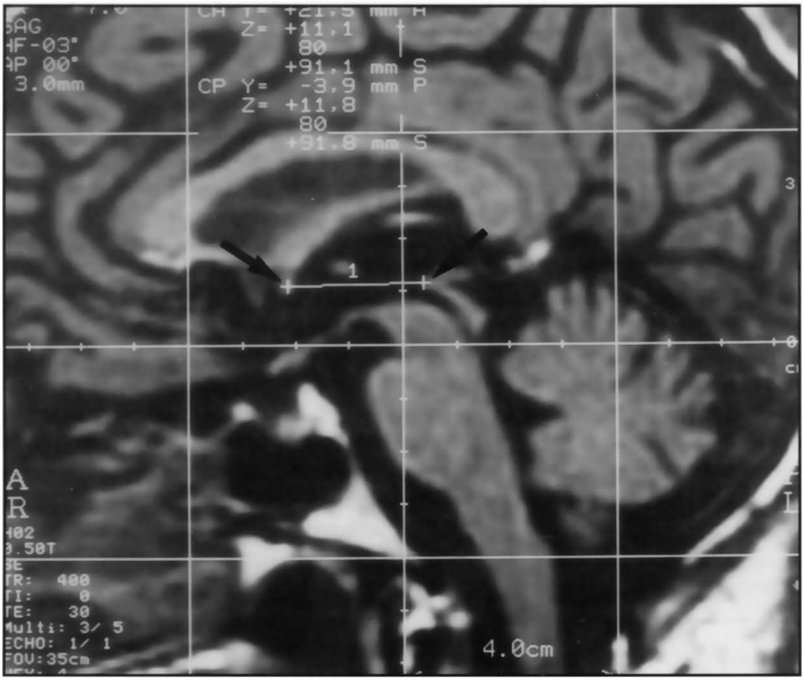

Fig 1. T1-weighted MRI sagittal section shows the anterior and posterior comissures (arrows) utilized for determination of the stereotactic target. Other deep structures can be also identified.

After determination of the stereotactic coordinates, a 1.8 mm electrode with a termocouple and uninsulated tip was introduced into the target through a frontal burr hole placed 2 cm from the midline. The target was confirmed through neurophysiological technique (electrical stimulation). Stimulation and lesion were performed utilizing a radiofrequency equipment (Radionics RFG-5S). The coagulation was made at 70° C for 60 seconds. Immediately after the coagulation, the control MRI shows perilesional edema, which completely subsides after three months. After this time, the size of the lesion has approximately 4 mm in diameter. When tremor was not completely abolished at this first coagulation, a second site was mapped and coagulated.

Table 1 depicts the distribution of the procedures accordingly to the imaging method.

Tremor was evaluated in the pre and postoperative period through the Clinical Rating Scale for Tremor (CRST), graded from 0 to 4[5]. Rigidity was graded from 0 to 3 in the preoperative period: 0 - absent; 1 - mild; 2 - moderate; 3 - severe. In the postoperative period, it was graded as improved (I), worse (W), and unchanged (U). Sialorrhea, abnormal gait, body imbalance, pain, dysarthria and motor fluctuations (on-off) were all rated as present (P) or absent (A) in the pre-operative period. In the postoperative period, these changes were rated as absent (A), improved (I), worse (W), and unchanged (U). All patients were re-evaluated from 3 to 18 months of follow-up.

RESULTS

Table 2 shows the difference of the stereotactic coordinates measured by ventriculography and CT-scan in 14 patients. Tables 3 and 4 depict the severity of tremor in the pre and postoperative periods in the MRI and VE groups, respectively. Tables 5 and 6 show the distribution of severity of rigidity in the MRI and VE in the pre and postoperative period.

Sialorrhea was a major symptom in 12 patients, 8 from MRI group and 4 from VE group. Table 7 shows the results in the postoperative period.

Gait changes prior and after stereotactic procedure are demonstrated in Tables 8 and 9.

Table 1. Distribution of stereotactic procedures accordingly to the imaging method.

Procedure	Ventriculography	MRI
Right thalamotomy	11	17
Left thalamotomy	14	8
Total	25	25

Table 2. Mean differences in the stereotactic coordinates of the anterior and posterior commissures obtained by ventriculography and CT scan.

Commissure	Coordinate	Mean (range) mm	SD
Anterior	y	2.71 (0-7,6)	2.02
Anterior	z	2.75 (0-6,0)	2.15
Posterior	y	2.84 (1-6,4)	2.09
Posterior	z	3.53 (0-7,0)	2.12

Table 3. MRI group: pre and postoperative tremor - CRST Scale.

Scale	Preoperative (%)	Postoperative (%)
0	-	21 (84)
1	2 (8)	4 (16)
2	13 (52)	-
3	8 (32)	-
4	2 (8)	-
Total	25 (100)	25 (100)

Table 4. VE group: pre and postoperative - CRST Scale

Scale	Preoperative (%)	Postoperative (%)
0	-	20 (80)
1	-	3 (12)
2	12 (48)	2 (8)
3	5 (20)	-
4	8 (32)	-
Total	25 (100)	25 (100)

Table 5. Rigidity: preoperative period

Scale	MRI (%)	VE (%)
0	-	-
1	11 (44)	7 (28)
2	12 (48)	15 (60)
3	2 (8)	3 (12)
Total	25 (100)	25 (100)

0, absent; 1, mild; 2, moderate; 3, severe

Table 6. Rigidity: postoperative period

Scale	MRI (%)	VE (%)
Absent	3 (12)	8 (32)
Improved	22 (88)	16 (64)
Unchanged	-	1 (4)
Total	25 (100)	25 (100)

Table 7. Sialorrhea: postoperative period of 12 patients.

Scale	MRI	VE
Absent	3	2
Improved	3	2
Unchanged	2	-
Worse	-	-
Total	8	4

Table 8. Gait disorder: preoperative period

Scale	MRI (%)	VE (%)
0	-	1 (4)
1	13 (52)	15 (60)
2	11 (44)	8 (32)
3	1 (4)	1 (4)
Total	25 (100)	25 (100)

0, absent; 1, mild; 2, moderate; 3, severe

Table 9. Gait disorder: postoperative period.

Scale	MRI (%)	VE (%)
Absent	1 (4)	3 (12)
Improved	19 (76)	20 (80)
Unchanged	5 (20)	1 (4)
Worse	-	1 (4)
Total	25 (100)	25 (100)

Table 10. Dysarthria: postoperative period.

Scale	MRI (%)	VE (%)
Absent	-	-
Improved	1 (5)	1 (5)
Unchanged	17 (85)	13 (65)
Worse	3 (15)	6 (30)
Total	21 (100)	20 (100)

Balance disorder was found in 8 patients (4 - MRI, 4 - VE) in the preoperative period. In each group, 3 patients improved after the surgical procedure, and 1 remained unchanged.

Pain was a prominent symptom in the ipsilateral more severely affected side in 10 patients (6 - MRI, 4 - VE). After surgery, 3 improved and 3 have no longer pain, in the MRI group. In the VE group, 2 improved and 2 did not complain of pain anymore.

Dysarthria was present in 41 cases (82%), in the preoperative period (21 - MRI, 20 - VE). Table 10 depicts the results in the postoperative period.

Worsening of dysarthria occurred only with procedures in the left hemisphere. All patients were right-handed.

Other complications included one patient who showed right transitory hemiparesis after a MRI-guided right thalamotomy. Another patient developed a permanent right hemiparesis after VE-guided left thalamotomy. Suture breakdown was seen in one patient. He was successfully treated under local anesthesia.

DISCUSSION

Stereotactic surgery has been used in the palliative treatment of Parkinson's disease with good results[7]. Tremor and rigidity may be improved with thalamotomy[6,27], while bradikynesia has shown better results with pallidotomy[11,17,18]. Ventriculography (VE) has been used as the standard imaging method to calculate the anatomical target[6]. In addition, electrical stimulation, evoked potentials and microelectrode recordings are used to confirm the site to be coagulated[14,25]. In spite of being considered a precise method, VE has shown several drawbacks, including headache, nausea, vomiting, and seizures[2,16,22]. Moreover, many patients with advanced Parkinson's disease have variable degrees of cerebral atrophy, increasing their risk to develop complications after ventricular puncture.

To circumvent such problems, CT-scan has been used in some centers[1,2,16]. In our 14 cases, the concomitant use of VE and CT-scan showed a remarkable difference in the measure of all coordinates, in special the supero-inferior coordinate (Z). While some cases showed a perfect matching of coordinates in both methods, in others a difference of up to 7 mm in the Z coordinate was observed. This mismeasure may be crucial, for a more inferior coagulation may lead to permanent lesion in the subthalamic nucleus with late hemiballismus. Too posteriorly located lesions may produce sensory deficits. Latero-lateral measures can be reliably determined with CT-scan, since structures such as third ventricle, thalamus, internal capsule and basal ganglia are directly observed. VE gives an indirect view of the third ventricle. In fact, Kelly[12] has reached the same conclusions with his own series and after analysis of other series[13].

MRI has made possible the direct inspection of intracranial structures in different planes. Better contrast resolution permits the precise identification of the internal capsule, thalamus and basal ganglia in the coronal and axial planes. Sagittal view allows excellent inspection of the anterior and posterior commissures. In our series, using MRI (25 cases) and VE (25 cases), we have observed good results in both groups. Abolition of tremor is a good indicator of success in stereotactic thalamotomy for Parkinson's disease. In the MRI group, tremor disappeared in 84% (21 cases), while tremor was abolished in 80% (20 cases) in the VE group. The remaining 16% (4 cases) of the MRI group showed remarkable improvement of tremor (grade 1).

Other clinical signs and symptoms showed comparable rate of improvement in both groups, MRI and VE.

Several studies have proposed the use of MRI for stereotactic functional procedures[3,4,15,20,24,26]. Different imaging distortions have been described with MRI. Sumanaweera et al.[28] reviewed with detail the different sources of spatial distortion in MRI images from the point of view of stereotactic target localization. Gradient field nonlinearities and magnetic field inhomogeneities are the most important sources of distortion, and some strategies to minimize such errors can be adopted.

MRI has proved to be as good as VE regarding the clinical results obtained in patients with Parkinson's disease. In conclusion, MRI may be used as a safe and accurate neuroimaging method for stereotactic thalamotomy, precluding the use of VE. In addition, debilitated patients may be benefited with a less aggressive imaging method for stereotactic procedures.

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