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Stereotactic surgery experience between the years 2000 and 2020 at the Central Military Hospital, Bogotá, Colombia

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Abstract

Introduction: Stereotactic surgery is a surgical technique with numerous diagnostic and therapeutic applications, enabling neurosurgeons to perform more precise and minimally invasive procedures compared to conventional surgery, thereby minimizing functional injuries. **Methodology**: A cross-sectional retrospective descriptive study was conducted, reviewing medical records of patients aged 18 and above who underwent stereotactic surgery between January 2000 and December 2020 at the Central Military Hospital (Bogotá, Colombia). **Results**: During the study period (January 2000 to December 2020), a total of 119 patients underwent stereotactic surgery for both diagnostic and therapeutic purposes, consisting of 44 women and 75 men. The majority of patients underwent intracranial tumor resection and biopsy. The complication rate was determined to be 4.2%. **Conclusions**: Stereotactic surgery proves to be a valuable surgical technique for diagnosing and treating various pathologies, exhibiting excellent diagnostic performance and a low complication rate. This study presents complication rates comparable to those reported in global literature, with this series being the only one analyzing the outcomes of this surgical technique in the population of the Colombian Military Forces.

Keywords: *Stereotaxy, stereotactic surgery, complications*

Introduction

Stereotactic surgery is a surgical technique that enables neurosurgeons to perform precise and minimally invasive procedures, minimizing the risk of functional lesions, in comparison to conventional surgery. Its origins trace back to 1908, when renowned neurosurgeon and neurophysiologist Sir Victor Horsley, in collaboration with mathematician and surgeon Robert Clarke, devised a stereotactic apparatus based on the Cartesian coordinate system for studying neurophysiology in primates. Subsequent advancements in the field occurred, culminating in 1946 when doctors Spiegel and Wycis accomplished the first functional surgery on a patient with Huntington's chorea, employing the initial human-use stereotactic frame and the advent of X-ray technology. To accurately locate anatomical targets, an atlas was manually crafted through meticulous biopsy observations. Since then, stereotaxy has been employed for the treatment of movement disorders like Parkinson's disease and essential tremors, chronic pain refractory to medical management, and psychiatric pathologies including aggression.[1] Moreover, it serves as a valuable tool for patients necessitating histological diagnosis of lesions in eloquent or deep areas, where size reduction of the suspected pathology is unnecessary, or in elderly individuals unable to undergo craniotomy due to comorbidities.[2] Additionally, stereotaxy has found utility in surgical drainage of brain abscesses, total resection of deep brain lesions such as cavernomas, and as a guide for ventricular catheters to address hydrocephalus, demonstrating a reduction in proximal shunt dysfunction rates.[3,4,5]

Stereotaxic surgery generally offers a safe approach for performing biopsies and other intracranial procedures, with mortality rates ranging from approximately 1% to 6%, and morbidity rates of 0% to 1.7%. The overall global complication rate is estimated to be 5%. Hemorrhage constitutes the majority, accounting for 60% of complications, while other commonly encountered issues include transient neurological deterioration and diagnostic performanceure.[6,7]

Methodology

A cross-sectional retrospective descriptive study was conducted, involving a review of medical records of patients aged 18 years and above who underwent stereotactic surgery at the Central Military Hospital (Bogotá, Colombia) between January 2000 and December 2020. The following variables were analyzed: age, sex, procedure objectives, histopathology reports, and complications.

During the implementation of this surgical technique, the Zamorano Dujovny stereotaxy framework with the Estereoplan® planning system was utilized from 2000 to 2016. Subsequently, the Micromar stereotaxy framework with the Aimplan® planning system was adopted.

Surgical technique

Upon patient selection for surgery, pre-surgical paraclinical tests are performed one day before the procedure. These tests include a complete blood count, coagulation times, renal function assessment, and specific paraclinical tests according to patients' comorbidities.

The patient is transferred to the operating room once the paraclinical tests confirm values within normal ranges. Before the surgery, a scalp block is administered by the neuroanesthesiology service. Subsequently, the stereotaxic frame is positioned, and the patient is then taken to undergo a contrast-enhanced skull tomography to facilitate the planning of the target and entry point.

Following the tomography, the patient is returned to the operating room to initiate the chosen anesthetic protocol tailored to the specific case at hand. For patient positioning, the base of the stereotaxic frame or the Mayfield support is utilized based on the surgeon's preference.

Results

During the study period from January 2000 to December 2020, a total of 119 patients underwent stereotaxy for diagnostic and therapeutic purposes. Of these patients, 44 were women and 75 were men (Figure 1). The age of the patients ranged from 18 to 87 years, with a mean age of 46.1 years. Among the patients, 56 (47.05%) underwent stereotaxy-guided craniotomy for resection of intracranial lesions, 48 (40.33%) underwent biopsy procedures, seven (5.88%) underwent electrode implantation for deep brain stimulation in Parkinson's disease, three (2.52%) underwent stereotaxy-guided ventricular catheter insertion for ventriculoperitoneal shunt, two (1.68%) underwent brain abscess drainage, two (1.68%) had previous diagnosis of craniopharyngioma and received Ommaya reservoir implantation, and one patient (0.84%) underwent intraparenchymal hematoma drainage.

Patients who underwent stereotactic biopsy as the surgical technique for histological diagnosis had lesions located in significant areas or had comorbidities that contraindicated a conventional craniotomy. Patients who underwent stereotactic-guided craniotomy for intracranial lesion resection had lesions in eloquent areas. (Table 1)

The most common histopathology reports revealed gliomas as the predominant tumor type, including diffuse astrocytoma (15.9%), glioblastomas (10.3%), oligodendroglioma (9.3%), anaplastic astrocytoma (7.5%), and pilocytic astrocytoma (6.5%). Meningiomas (5%) and lung metastases (5%) were also observed. Ten patients were diagnosed with cavernous angioma, while toxoplasmosis was the most frequent infectious pathology. Among the 107 patients who underwent tissue sampling, only two cases reported insufficient samples for histological diagnosis, resulting in a diagnostic yield of 98.1%. Histopathological samples were not obtained in 12 cases, including seven patients with Parkinson's disease, three patients who underwent ventriculoperitoneal bypass, and two patients with known craniopharyngioma, where Ommaya reservoir implantation was performed as part of medical treatment (Table 2).

Figure 1. Gender distribution

Table 1. Population characteristics

	Man	Woman	Total
Population	75	44	119
Age (median)	45.5	46.8	46.1
Lesion resection	35	21	56
Intracranial lesion biopsy	33	15	
Lesion in eloquent area	26	10	
Comorbidities	7	5	48
Deep brain stimulation for Parkinson's disease	5	2	7
Ventriculoperitoneal shunt (idiopathic intracranial hypertension)	0	3	3
Brain abscess drainage	1	1	2
Ommaya reservoir implantation	0	2	2
Intraparenchymal hematoma drainage	1	0	1

A total of five patients experienced complications, representing 4.2% of the total cases. The first case involved a female patient who underwent resection of a left parietal lesion (oligodendroglioma) and subsequently developed hypoesthesia in the right upper limb. The second case involved a patient who underwent deep brain stimulation for Parkinson's disease and experienced a superficial operative site infection on one of the surgical wounds, necessitating prolonged antibiotic management and eventual electrode removal. The third case involved a male patient who underwent a biopsy of a suprasellar lesion and presented with postoperative headache and intraventricular bleeding, requiring reoperation for drainage. The fourth case involved a male patient who underwent resection of a frontal astrocytoma and experienced neurological deterioration in the immediate postoperative period, subsequently developing hydrocephalus due to intraventricular bleeding and requiring reoperation for drainage. The fifth patient underwent resection of a metastatic lesion and developed an infection at the surgical site, requiring reintervention for site irrigation. (Table 3)

Discussion

Stereotaxic surgery is a widely utilized, effective, and relatively low-risk approach for patients requiring resection or biopsy of intraaxial lesions, where performing a craniotomy would pose increased morbidity and mortality risks.

Table 2. Pathological reports of HOMIC stereotactic surgery (2000-2019)

Pathology report	
Tumors	
Diffuse astrocytoma	17
Glioblastoma	11
Oligodendroglioma	10
Anaplastic astrocytoma	8
Pilocytic astrocytoma	7
Meningioma	5
Lung metastases	5
B-lymphoma	4
Ependymoma	2
Nodular sclerosis-type classical non-Hodgkin lymphoma	2
Germinoma	2
Gangliobasal giant cell glioma	1
Multifocal anaplastic ganglioglioma	1
Hemangiopericytoma	1
Oligoastrocytoma	1
Dysembryoplastic neuroepithelial tumor (glial tumor)	1
Vascular	
Cavernous angioma	10
Infections	
Toxoplasmosis	6
Cerebritis	4
Brain tissue with necrosis and inflammation suggesting bacterial etiology	3
Blastomycosis	1
Meningoencephalitis	1
Autoimmune	
Demyelinating process with macrophages	1
Others	
N/A (Parkinson's disease, hydrocephalus, craniopharyngioma)	12
Insufficient sample	2
Radionecrosis	1
Total	119

The estimated mortality rate for stereotactic biopsy ranges from 0% to 4%, with risk factors including lesion location in the basal ganglia, lymphoma histopathology, and neovascularized lesions. Morbidity is estimated to be around 0% to 1.7%, with transient or permanent neurological deficits, seizures, or altered state of consciousness being the most commonly observed complications. Independent risk factors include diabetes lesions in the thalamus or basal ganglia.[2,8,9]

Table 3. Complications of HOMIC stereotactic surgery (2000-2019)

Procedure	Total	Sensory lesion	ISO	Intraventricular bleeding
Intracranial lesion resection	56 (47%)	1	1	1
Diagnosis by biopsy	48 (40%)	-	-	1
Deep brain stimulation for Parkinson's disease	7 (6%)	-	1	-
Ventriculoperitoneal shunt	3 (2%)	-	-	-
Brain abscess drainage	2 (2%)	-	-	-
Ommaya reservoir implantation for the treatment of craniopharyngioma	2 (2%)	-	-	-
Intraparenchymal hematoma drainage	1 (1%)	-	-	-
Total patients	119 (100%)			
Complications	5 (4.2%)	1	2	2

Among patients undergoing stereotactic biopsies, intraparenchymal hemorrhage is the most frequently reported complication, with rates varying from 0.9% to 8.6%. It has been associated with hydrocephalus, intracranial hypertension, lymphoma histology, cerebral edema, and the use of antiplatelet drugs within 48 hours before surgery. Infection, although rare, is generally linked to chronic corticosteroid use.[8]

For stereotactic surgery employed in the treatment of movement disorders, an estimated intraoperative bleeding rate of 9.5% is observed, primarily caused by coagulation induced by radiofrequency or following electrode implantation. In patients undergoing deep brain stimulation, infection rates of up to 28%, system fracture in 13%, electrode migration in 6% and disconnections in 4% have been reported.[10,11]

This study reveals that the most common stereotactic procedures performed at the Central Military Hospital are intracranial tumor resection, followed by tumor biopsies. The most prevalent tumor pathology observed is diffuse gliomas, followed by meningiomas and metastatic lesions. Stereotaxy is also used for biopsies of infectious lesions such as toxoplasmosis, brain abscess drainage, electrode placement for deep brain stimulation, and shunt catheter positioning. The overall complication rate was found to be 4.2%, with hemorrhage and infection being the most frequent complications, occurring at rates of 1.6% each. Neurological injuries were observed in 0.8% of the total patient cases. Notably, the rate of complications in the Central Military Hospital falls within the range reported in the literature.

Regarding diagnostic performance, the literature suggests that adequate histological diagnosis is achieved in over 90% of stereotactic procedures, with influential factors including lesion location, morphology, surgical planning, and frozen biopsies. In our study, the diagnostic yield was determined to be 98.1%.[12]

Conclusions

Stereotactic surgery proves to be a valuable surgical technique for diagnosing and treating various pathologies, demonstrating excellent diagnostic performance and a low rate of complications. The findings of this study present complication rates comparable to those reported in global literature. It is noteworthy that this series is the only one analyzing the outcomes of this surgical technique specifically in the population of the Colombian Military Forces.

Conflict of interests

The authors declare no conflict of interest.

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