Archives of Neurosurgery

Volume 1 | Issue 2 | Article 11

2022

Archives of Neurosurgery Volume 1 Issue 2 - Full Issue

ARCHIVES OF NEUROSURGERY REVISTA DE DIVULGACIÓN CIENTÍFICA DE LA SOCIEDAD MEXICANA DE CIRUGÍA NEUROLÓGICA A.C., Año 1, No.2 (junio a diciembre 2022) es una publicación cuatrimestral editada por la Sociedad Mexicana de Cirugía Neurológica A.C., Miami 47, Nápoles, Benito Juárez, 03810 Ciudad de México, CDMX, Tel 52 (55) 5543 0013, https://www.ansjournal.org. Editor: Fiacro Jiménez Ponce. Reserva de Derechos al Uso Exclusivo No. 04-2023-051212055700-102, ISSN: En trámite, ambos otorgados por el Instituto Nacional del Derecho de Autor. Responsable de la última actualización de este número Fiacro Jiménez Ponce, Miami 47, Nápoles, Benito Juárez, 03810 Ciudad de México, CDMX, fecha de última modificación 31 de diciembre del 2022.

Archives of Neurosurgery Volume 1 Issue 2 - Full Issue

Abstract
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Visual Abstract

ARCHIVES OF NEUROSURGERY
Vol I. Issue II. Jan. 2022
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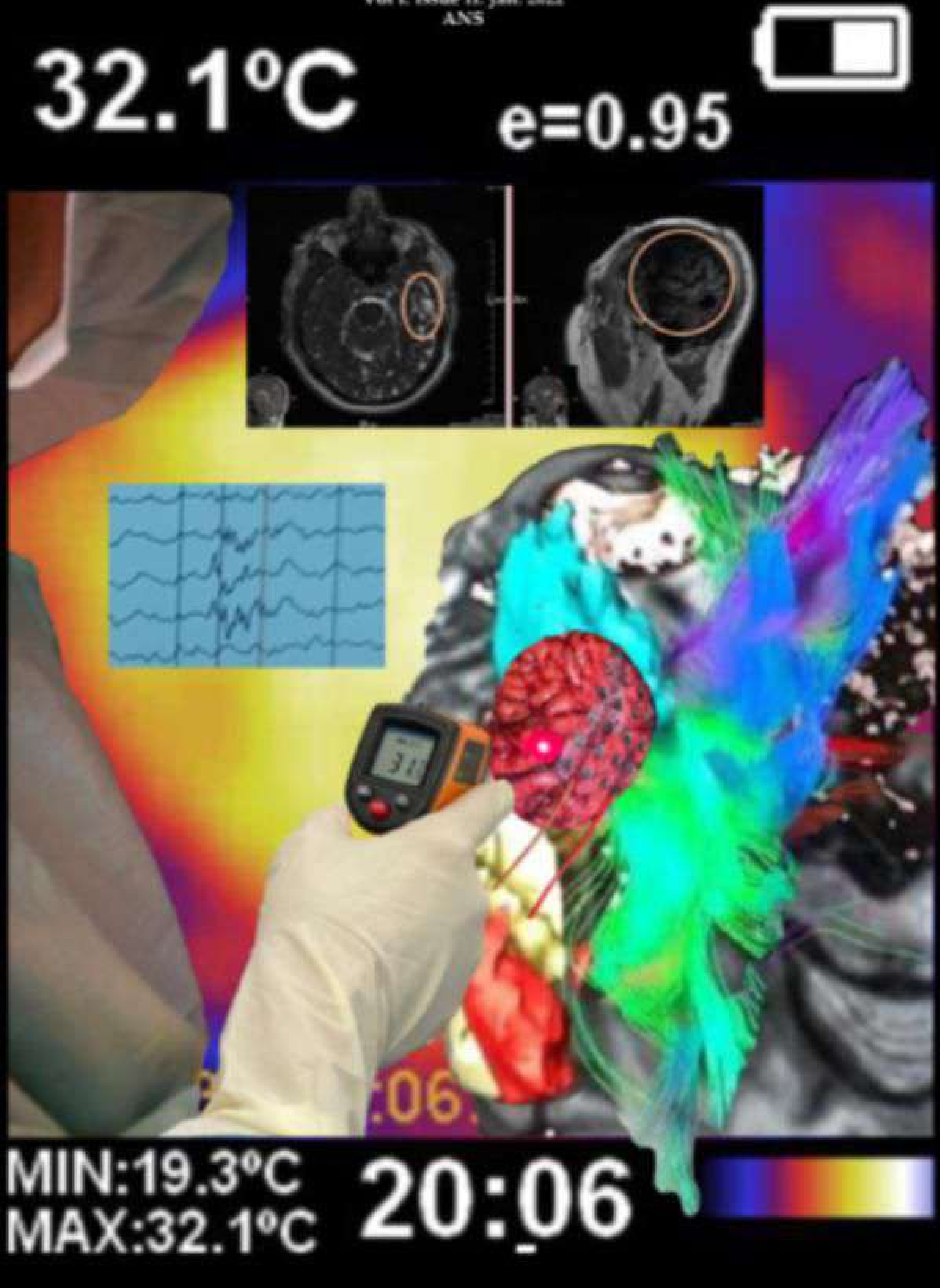

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Archives of Neurosurgery

Volume 1 | Issue 2 Article 1

2020

Issues to Publish in Latin America

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ARCHIVES OF NEUROSURGERY REVISTA DE DIVULGACIÓN CIENTÍFICA DE LA SOCIEDAD MEXICANA DE CIRUGÍA NEUROLÓGICA A.C., Año 1, No.2 (enero a junio 2022) es una publicación cuatrimestral editada por la Sociedad Mexicana de Cirugía Neurológica A.C., Miami 47, Nápoles, Benito Juárez, 03810 Ciudad de México, CDMX, Tel 52 (55) 5543 0013, https://www.ansjournal.org. Editor: Fiacro Jiménez Ponce. Reserva de Derechos al Uso Exclusivo No. 04-2023-051212055700-102, ISSN: En trámite, ambos otorgados por el Instituto Nacional del Derecho de Autor. Responsable de la última actualización de este número Fiacro Jiménez Ponce, Miami 47, Nápoles, Benito Juárez, 03810 Ciudad de México, CDMX, fecha de última modificación 22 de junio del 2022.

Issues to Publish in Latin America

Abstract

Scientific knowledge is essential to the development of civilization, particularly in our case for anatomy and physiology of the central nervous system and neurosurgical practice. In this editorial, we are reviewing three critical aspects of scientific publications: The scientific training of physicians, the impact of publications, and the ethical aspects related to elaborating a paper.

Visual Abstract

Keywords

Scientific productivity, Publishing Issues, Latin America, Low-Middle Income Countries, Neurosurgery

Authors

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Issues to Publish in Latin America

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Keywords: Scientific productivity, Publishing issues, Latin America, Low-middle income countries, Neurosurgery

Scientific knowledge is essential to the development of civilization, particularly in our case for anatomy and physiology of the central nervous system and neurosurgical practice. In this editorial, we are reviewing three critical aspects of scientific publications: The scientific training of physicians, the impact of publications, and the ethical aspects related to elaborating a paper.

Neurosurgical activity is indeed a challenge with a unique manner in the countries of Hispanic America, in that the probability of publishing a scientific paper with enough quality is reduced by cause of insufficient methodologic preparation of the health professional. Usually, the university medicine programs do not include several topics such as epistemology, scientific methodology, statistical science, and writing article skills. Frequently, colleagues delve into the complex art to write their results or experience, unattended whether the study is observational, a clinical trial, or a diagnostic test. In sometimes, they are not aware that the statistical test is adequate to the design. So, the logical result is that a high percentage of papers have significant observations, or in the worst cases, they are rejected. In Mexico, a healthy person takes around 8.35 years to finish postgrad training [1]. In consequence, the successful neurosurgical scientific publications are elaborated by the most professional groups that have been formed in research and surgery. Nowadays, the chance to complete neurosurgical training with scientific professionalization is increasing but still is not enough. On the other hand, the percentage of Gross Domestic Product (GDP) varies greatly depending on each country. Generally developed countries applied to research and technology innovation around 3% of GDP, and these founds come from industrial and business activities (Fig. 1) [1]. In Iberoamerica, Brazil has the most prominent scientific inversion, with 1.6% of its GDP.

In contrast, Mexico invests just 0.3% of its GDP. Thus, another relevant fact is a minimal relationship between the private sector and scientific development in Latin America. On the other hand, investment in research in the First World comes in more than 50% from the private sector (Fig. 1) [1].

We must also consider that the authors could feel unmotivated to publish due to the time spent in the revision by a peer, the number of observations for reviewers, the style revision, the process of re-submission, and the final editorial process—usually, the average time to publish a study in a year. Further, the cost of getting a paper is increasing due to the payment of translation and style revision. Additionally, several journals could have an extra fee for the number of colors of figures. So, the amount needed to present a publication could be between 200 and 2500 USD. Companies specialize in providing advice on translation, style, and application management to specific journals. Examples of these are American Journal Expert [2] o American Manuscript Editors [3].

Received 6 November 2021; revised 6 November 2021; accepted 6 November 2021.
Available online ■ ■ ■

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Peer review under responsibility of Transdisciplinary University, Bangalore.

ISSN-Pending. Published by Mexican Society of Neurological Surgery (Sociedad Mexicana de Cirugía Neurológica A.C.).

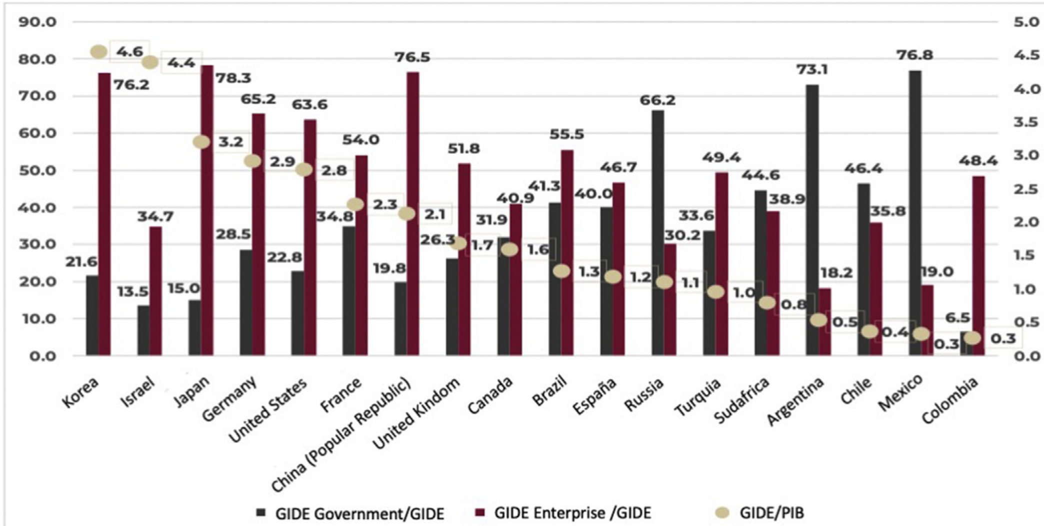

Fig. 1. GIDE for strategic countries to Mexico. 1. Information taken and translated from CONACyT. CONACyT is not responsible for any translation imprecision.

Currently, the scientific journals can be rated by the Journal Impact Factor (JIF) that is provided for several organizations as Journal Citation Reports - Web of Science – Clarivate [4]. According to this index, until July 2018, there were 12,986 journals listed in this metric. The JIF values range from 0.000 to 508.702. This value is calculated by adding the total number of citations from two previous years and dividing by the total number of publications in the same period. So, JIF for 2021 derives from citations from 2019 to 2021 for a specific journal [5]. The biggest JIF in 2021 was CA: A Cancer Journal of Clinicians (JIF: 508), then much lower appears Nature Reviews Molecular Cell Biology (JIF: 94.444), New England Journal of Medicine (JIF: 91.245), Nature Review Drugs Discovery (JIF: 84.694) and Lancet (JIF: 79.321). The JIF and accessibility to studies in each journal are essential elements that authors and readers look for when publishing or reading. This situation means that a journal with higher JIF and better accessibility will be reading and refereed many times more than others with lower JIF. So, the editorial team will be looking found the procedures to increase the quality of scientific and ethical requirements at the same time to decrease timing for publication.

The National Council for Science and Technology (CONACyT) of Mexico has published the three major countries contributing to the worldwide productivity of scientific journals in 2018. The United States and Austria have 16.63% each of this production while China has 15,28%.

The add of five principal countries of Latin America is 3.56% (Brazil – 2.0%, Mexico – 0.67%, Argentina – 0.40%, Chile – 0.4% and Colombia –0.24%) (Tables 1 and 2) [1].

However, the highest average JIF for five years period (2014–2018) were Island (1.96), Estonia (1.78), and Switzerland (1.65), considering the highest impact over the number of publications [1]. In Iberoamerica, we can observe that most citied papers came from Colombia and Chile, each with 1.15. Meanwhile, Argentina had 0.95, Brazil 0.85, and Mexico 0.83 [1]. It is fascinating to notice that there is no direct correlation between the GDP and JIF of journals.

Additionally, the authors of medical scientific studies must observe if their protocols include investigation subjects as clinical trials, cohort studies, and diagnostic tests to review the mandatory ethics and regulatory research aspects. The clinical journals ask about the Investigational Research Board (IRB) approbation and the Biosecurity Board in some cases. It is necessary to declare the interest conflicts, the role of each participant has in the study, and of course, the absence of plagiarism, self-plagiarism, or different forms of scientific fraud. Usually, the Author's Guidelines establish these rules. Indeed, today is essential to declare and show that the team of researchers has acted with rigorous scientific methodology according to world bioethical norms, particularly with these special rules that the journal established. Given the relevance that bioethics has taken, neuroethics appeared as a new and vital area

Table 1. Relation between Global Domestic Product and participation percentage in the global production of scientific papers. 1. Information taken and translated from CONACyT. CONACyT is not responsible for any translation imprecision.

OCDE									
Position	Country	Gross Domestic Product per capita	Participation Percentage in the Global Production of Scientific Papers		Position	Country	Gross Domestic Product per capita	Participation Percentage in the Global Production of Scientific Papers	
			2018	2014–2018				2018	2014–2018
1	United States	59,927.93	16.63	17.75	19	Austria	53,879.30	16.63	17.75
2	United Kingdom	44,896.26	5.15	5.38	20	Mexico	19,432.21	5.15	5.38
3	Germany	52,574.26	4.53	4.73	21	Norway	62,182.24	4.53	4.73
4	Japan	41,958.96	3.22	3.38	22	Israel	38,867.76	3.22	3.38
5	France	44,255.94	2.98	3.20	23	Portugal	32,554.30	2.98	3.20
6	Canada	46,723.32	2.84	2.96	24	Finland	46,348.96	2.84	2.96
7	Italy	40,981.28	2.77	2.86	25	Czech Republic	38,019.58	2.77	2.86
8	Australia	49,653.72	2.71	2.76	26	Greece	28,579.79	2.71	2.76
9	Spain	39,037.38	2.45	2.53	27	New Zealand	20,438.57	2.45	2.53
10	South Korea	38,824.12	2.43	2.48	28	Chile	24,248.86	2.43	2.48
11	Netherlands	54,503.08	1.66	1.72	29	Ireland	77,596.36	1.66	1.72
12	Switzerland	66,299.63	1.30	1.33	30	Hungary	28,798.64	1.30	1.33
13	Sweden	51,404.79	1.19	1.21	31	Slovenia	36,153.38	1.19	1.21
14	Turkey	27,878.61	1.19	1.25	32	Slovakia	32,371.22	1.19	1.25
15	Poland	29,930.99	1.18	1.19	33	Estonia	33,447.83	1.18	1.19
16	Belgium	49,411.87	0.93	0.97	34	Luxembourg	107,640.56	0.93	0.97
17	Denmark	54,356.45	0.81	0.82	35	Iceland	55,322.09	0.81	0.82
18	Lithuania	33,252.84	0.86	0.00	36	Latvia	28,362.14	0.86	0.00
Latin America					**BRICS**				
1	Brazil	15,662.25	2.00	1.94	1	China	16,782.21	15.28	13.14
2	México	19,432.21	0.67	0.63	2	India	7168.99	2.91	2.81
3	Argentina	20,843.16	0.40	0.40	3	Brazil	15,662.25	2.00	1.94
4	Chile	24,248.86	0.40	0.38	4	Russia	25,766.93	1.60	1.55
5	Colombia	14,507.26	0.23	0.21	5	Mexico	19,432.21	0.67	0.63
					6	South Africa	13,458.96	0.61	0.60

Table 2. Relation between Global Domestic Product and Normalized Citation Impact Average. 1. Information taken and translated from CONACyT. CONACyT is not responsible for any translation imprecision.

OCDE							
Position	Country	Gross Domestic Product per capita	Normalized Citation Impact Average	Position	Country	Gross Domestic Product per capita	Normalized Citation Impact Average
			2014–2018				2014–2018
1	Iceland	55,322.09	1.96	19	Germany	52,574.26	1.29
2	Estonia	33,447.83	1.78	20	Greece	28,579.79	1.29
3	Switzerland	66,299.63	1.65	21	Israel	38,867.76	1.29
4	Luxembourg	107,640.56	1.65	22	Latvia	28,362.14	1.25
5	Denmark	54,356.45	1.60	23	France	44,255.94	1.25
6	Netherlands	54,503.08	1.59	24	Spain	49,653.72	1.22
7	Belgium	49,411.87	1.49	25	Portugal	32,554.30	1.21
8	Ireland	77,596.36	1.47	26	Hungary	28,798.64	1.21
9	Norway	62,182.24	1.45	27	Slovenia	36,153.38	1.16
10	Sweden	51,404.79	1.45	28	Chile	24,248.86	1.15
11	Austria	53,879.30	1.43	29	Czech Republic	38,019.58	1.07
12	Finland	46,348.96	1.43	30	Slovakia	32,371.22	1.02
13	United Kingdom	44,896.26	1.42	31	Lithuania	33,252.84	1.02
14	Australia	49,653.72	1.40	32	South Korea	39,037.38	0.93
15	Canada	46,723.32	1.33	33	Poland	29,930.99	0.91
16	New Zealand	20,438.57	1.32	34	Japan	41,958.96	0.90
17	Italy	40,981.28	1.30	35	Mexico	19,432.21	0.83
18	United States	59,927.93	1.30	36	Turkey	27,878.61	0.74
Latin America				**BRICS**			
1	Brazil	15,662.25	1.15	1	South Africa	13,458.96	1.18
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3	Argentina	20,843.16	0.95	3	Brazil	15,662.25	0.85
4	Brazil	15,662.25	0.85	4	Mexico	19,432.21	0.83
5	México	19,432.21	0.83	5	India	7168.99	0.81
				6	Russia	25,766.93	0.68

of neuroscience several years ago. This issue has been represented by the Mexican Association of Neuroethics [6], an institution where many countries of Iberoamerica participate. This association is attached to the International Neuroethics Society [7]. After analyzing the previous information, we can reflect on the effect Archives of Neurosurgery can have in the neurosurgical context. It is a Journal by a pear review editorial process, published in English, in electronic format, and includes several neurosurgical fields, and it has no cost for the authors although it is an Open Access Journal. In this second issue of Archives of Neurosurgery, we publish original studies, case reports, literature reviews, and videos from many Latin American countries. Archives of Neurosurgery aims to be an accessible international forum with methodologic and ethical criteria needed to be an option for worldwide authors. The main challenge of Archives of Neurosurgery is to maintain the pace of quality required to obtain inclusion into Medline Library. We think that is possible because many neurosurgeons are looking for a special periodic publication.

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Archives of Neurosurgery

Volume 1 | Issue 2 Article 2

2020

Microvascular Decompression for Hemifacial Spasm: Surgical Technical nuances and results after 300 microvascular decompression surgeries

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Microvascular Decompression for Hemifacial Spasm: Surgical Technical nuances and results after 300 microvascular decompression surgeries

Abstract

Introduction: Hemifacial spasm (HFS) is characterized by the involuntary, paroxysmal, painless, and progressive spasmodic contractions of facial muscles innervated by the ipsilateral seventh cranial nerve. To date, neuroimaging studies (Computed Tomography scan [CT] and Magnetic Resonance Imaging [MRI]) are unable to establish the diagnosis. HFS medical treatment with antiepileptic drugs, and Botulinum toxin application are temporarily effective, however, both have shown side effects and lesser cost-effective results. Currently, surgical Micro Vascular Decompression (MVD) for HFS has the highest curative rates and lower operative morbidity. We analyze the demographics, clinical manifestations, outcomes, and complications that to our knowledge, is the largest Latin-American patient's series treated for HFS through a keyhole microasterional craniectomy. Objective: The authors report the results of 300 Microvascular Decompression (MVD) for Hemifacial Spasm (HFS) in 265 patients due to nerve attrition by the neurovascular etiology, triggering of ectopic action potentials from the demyelinated facial nerve fibers. Methods: We reviewed and analyzed the clinical data from the medical records of patients treated by MVD for HFS from May 1992 to December 2018. Both preoperative MRI and audiometry studies were assessed in all patients as part of preoperatively evaluation. Patients with secondary causes of HFS such as tumors were excluded. Results: Among them, 168 [63.4%] were women and 97 [36.6%] males. 149 (56.2%) HFS were left-sided and with a better outcome compared to the 116 (43.8%) located on right side (p=0.22). The two main culprit vessels were AICA in 188 (70.9%) followed by PICA in 20 (7.5%). The basilar artery was identified in 14 (5.3%) and SUCA in 13 (4.9%). Conclusions: MVD through a retractorless microasterional approach is a very effective and a safe technique for treating HFS. Failure to HFS improvement after 1-week of MVD warrants immediate reoperation. In addition, MVD is a safe, the most effective technique and the only curative treatment for HFS.

Visual Abstract

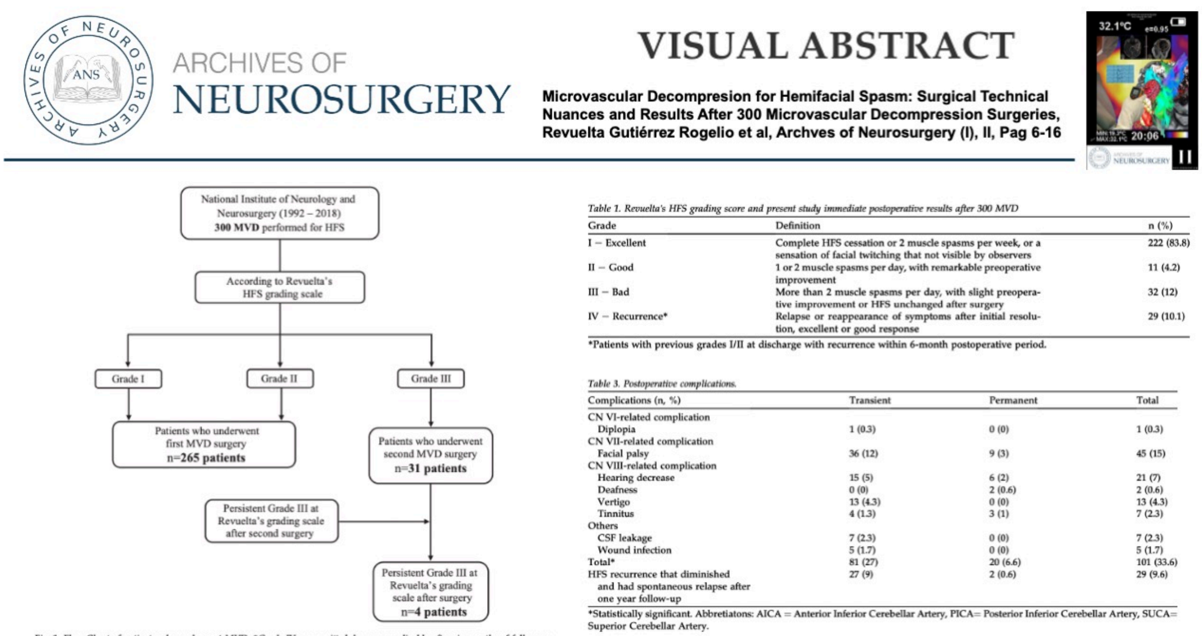

Table 1. Revuelta's HFS grading score and present study immediate postoperative results after 300 MVD

Grade	Definition	n (%)
I – Excellent	Complete HFS cessation or 2 muscle spasms per week, or a sensation of facial twitching that not visible by observers	222 (83.8)
II – Good	1 or 2 muscle spasms per day, with remarkable preoperative improvement	11 (4.2)
III – Bad	More than 2 muscle spasms per day, with slight preoperative improvement or HFS unchanged after surgery	32 (12)
IV – Recurrence*	Relapse or reappearance of symptoms after initial resolution, excellent or good response	29 (10.1)

*Patients with previous grades I/II at discharge with recurrence within 6-month postoperative period.

Table 3. Postoperative complications.

Complications (n, %)	Transient	Permanent	Total
CN VI-related complication			
Diplopia	1 (0.3)	0 (0)	1 (0.3)
CN VII-related complication			
Facial palsy	36 (12)	9 (3)	45 (15)
CN VIII-related complication			
Hearing decrease	15 (5)	6 (2)	21 (7)
Deafness	0 (0)	2 (0.6)	2 (0.6)
Vertigo	13 (4.3)	0 (0)	13 (4.3)
Tinnitus	4 (1.3)	3 (1)	7 (2.3)
Others			
CSF leakage	7 (2.3)	0 (0)	7 (2.3)
Wound infection	5 (1.7)	0 (0)	5 (1.7)
Total*	81 (27)	20 (6.6)	101 (33.6)
HFS recurrence that diminished and had spontaneous relapse after one year follow-up	27 (9)	2 (0.6)	29 (9.6)

*Statistically significant. Abbretiatons: AICA = Anterior Inferior Cerebellar Artery, PICA= Posterior Inferior Cerebellar Artery, SUCA= Superior Cerebellar Artery.

Keywords
Hemifacial Spasm, Microvascular Decompression, Asterional approach

Authors
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Microvascular Decompression for Hemifacial Spasm: Surgical Technical Nuances and Results After 300 Microvascular Decompression Surgeries

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Abstract

Introduction: **Hemifacial spasm (HFS) is characterized by the involuntary, paroxysmal, painless, and progressive spasmodic contractions of facial muscles innervated by the ipsilateral seventh cranial nerve. To date, neuroimaging studies (Computed Tomography scan [CT] and Magnetic Resonance Imaging [MRI]) are unable to establish the diagnosis. HFS medical treatment with antiepileptic drugs and Botulinum toxin application is temporarily effective; however, both have shown side effects and lesser cost-effective results. Surgical microvascular decompression (MVD) for HFS has the highest curative rates and lower operative morbidity. We analyze the demographics, clinical manifestations, outcomes, and complications of an HFS patient's series treated through a keyhole microasterional craniectomy that, to our knowledge, is the most extensive among Latin America.**

Objective: **The authors report the results of microvascular decompression (MVD) for hemifacial spasm (HFS) due to nerve attrition by a neurovascular etiology.**

Methods: **We reviewed and analyzed the clinical data from patients' medical records treated by MVD for HFS from May 1992 to December 2018. We only included patients with a neurovascular etiology while excluded any other causes such as tumors. We assessed both preoperative MRI and audiometry studies in all patients as part of preoperative evaluation.**

Results: **Two-hundred sixty-five patients underwent three-hundred MVD for HFS; among them, 168 [63.4%] were females and 97 [36.6%] males. One-hundred forty-nine (56.2%) HFS were left-sided located and one-hundred sixteen (43.8%) right-sided. The two main culprit vessels were AICA in one-hundred eighty-eight cases (70.9%), followed by PICA in twenty (7.5%), followed by the basilar artery in fourteen (5.3%), and the SUCA in thirteen (4.9%).**

Conclusions: **MVD through a retractor-less microasterional approach is a very effective and safe technique for treating HFS. In addition, MVD is the only curative treatment for HFS; therefore, failure to improve after 1-week of MVD warrants immediate reoperation for HSF.**

Keywords: Hemifacial spasm, Microvascular decompression, Asterional approach

1. Introduction

Hemifacial spasm (HFS) is characterized by involuntary, paroxysmal, painless, and progressive spasmodic contractions of facial muscles innervated by the ipsilateral seventh cranial nerve [1–10]. HFS tends to be predominantly left-sided and to have a 2:1 preponderance ratio over the female gender [11,12]. The HFS prevalence has been

Received 24 June 2020; revised 4 September 2020; accepted 3 November 2020.
Available online ■ ■ ■

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Peer review under responsibility of Transdisciplinary University, Bangalore.

reported in 10 cases/100,000 people [13,14] being primarily patients over the fifth decade of life [6,11].

HFS is classified as typical and atypical [11,12,15] according to the initial twitching manifestation and rendering to the occurrence in the superior or inferior half of the face, respectively. While untreated, the overall tendency is to worsen over time [4,9] with the potential to develop various grades of facial palsy [16,17]. HFS is referred to as "tic convulsive" when co-occurring with trigeminal neuralgia (TN), as Cushing's first description in 1920 [18]. Though HFS occurs unconsciously, it can be elicited by triggering maneuvers and psychogenic stimuli [4,11,19]. Even though HFS contractions decrease during rest, HFS and palatal myoclonus persist during sleep [2,20–23]. Medical treatment with carbamazepine, clonazepam, and gabapentin can only achieve poor and transient improvement [9,24,25]. Botulinum toxin type A in HFS has shown improvement of 75–100% [26,27]; however, beneficial effects are temporary and periodic applications are required [3,5,9,24]. In addition, botulinum toxin type A is not innocuous, carries potential side effects, and has a lesser cost-effective result [9,28–30].

The clinical features of HFS at examination (e.g., facial twitching) are keys for the diagnosis; however, ancillary tests such as electromyography (EMG) can also be of help [24,25,31]. Neuroimaging studies alone cannot establish the diagnosis; nevertheless, computed tomography scan (CT-scan) [25,32,33], magnetic resonance imaging (MRI) [4,24,34–39], and hemodynamic studies [40] are valuable tools to rule out posterior fossa pathology other than vascular compression. Authors have hypothesized the mechanism of HFS to be the result of the pulsatile cross-compression over the seventh (facial-VII) within the Root Entry/Exit Zone (REZ) by 1 or 2 arterial loops [3–5,34] causing an ephaptic transmission between individual nerve cells fibers dropped the excitability threshold of the neurons in the compression zone [31,41,42]. The Anterior Inferior Cerebellar Artery (AICA) [3,43] and the Posterior Inferior Cerebellar Artery (PICA) [44–46], are considered the main culprit vessels involved in the compression, varying its frequency depending on the series.

Since Jannetta established and popularized the MVD technique in the 1970s [17,44,46–48], technical improvements have allowed other surgeons to perform MVD with minimally invasive approaches [12,20,25,38,44,49,50]. Currently, MVD for HFS has cure rates up to 90% and operative morbidity of less than 10% [11,30,51,52] being the only curative option that "treats" the cause of HFS hemifacial spasm.

Abbreviations

MVD	Micro Vascular Decompression
MRI	Magnetic Resonance Imaging
TN	Trigeminal Neuralgia
REZ	Root Entry Zone
AICA	Anterior Inferior Cerebellar Artery
PICA	Posterior Inferior Cerebellar Artery
SUCA	Superior Cerebellar Artery
EMG	Electromiography
CT	Computed Tomography
NINN	National Institute of Neurology and Neurosurgery
HB	House Brackman
CPA	Cerebello pontine angle
CSF	Cerebrospinal fluid
SD	Standard Deviation
IQR	Inter Quartile Range
BAEP	Brainstem Auditory Evoked Potentials
FIESTA	Fast Imaging Employing Steady-State Acquisition

This study aims to analyze the demographics, clinical manifestations, outcomes, and complications of an HFS patient's series treated through a keyhole microasterional craniectomy that, to our knowledge, is the most extensive among Latin America.

2. Patients and methods

We reviewed and analyzed the clinical data and medical files of patients treated with MVD for HFS from May 1992 to December 2018; we made this study in adherence to STROBE guidelines for retrospective observational cohorts. We only included patients with a neurovascular etiology while excluded any other causes such as tumors. We assessed both preoperative MRI and audiometry studies in all patients as part of preoperative evaluation. Our institutional ethics board approved this study.

2.1. Data collection and follow-up

We collected data including age, sex, previous medical history, duration of HFS, previous nonsurgical treatments, complications, and presence or absence of HFS at the time of hospital discharge. HFS outcome was set on the relief of symptoms and classified according to the previously described Revuelta's HFS score-criteria [12,53] (see Table 1): "Spasm free" group, grades I (Excellent) and II (Good); and 2) "Spasm-relapse," grades III (bad) and IV (recurrence). In addition, we also registered surgical findings such as the offending vessel, intraoperative photos, or video recordings for each case. All patients were followed for at least six months after surgery on consecutive assessments at the outpatient clinic.

Table 1. Revuelta's HFS grading score and present study immediate postoperative results after 300 MVD

Grade	Definition	n (%)
I – Excellent	Complete HFS cessation or 2 muscle spasms per week, or a sensation of facial twitching that not visible by observers	222 (83.8)
II – Good	1 or 2 muscle spasms per day, with remarkable preoperative improvement	11 (4.2)
III – Bad	More than 2 muscle spasms per day, with slight preoperative improvement or HFS unchanged after surgery	32 (12)
IV – Recurrence*	Relapse or reappearance of symptoms after initial resolution, excellent or good response	29 (10.1)

*Patients with previous grades I/II at discharge with recurrence within 6-month postoperative period.

Postoperative complications that recovered spontaneously within the first 6-months after surgery were assigned as "transient" and "permanent" when persisted after six months. We used the House- Brackmann (HB) score to establish the facial palsy grade, while we assessed hearing loss comparing to a preoperative audiological evaluation [54]. In both cases, we measured the duration of symptoms after MVD.

2.2. Technical nuances and surgical technique

All surgeries were performed by a senior Neurosurgeon (R.R.G), excluding potential bias related to surgeon skills and experience [55].

2.3. Patients position

We performed all MVDs under general anesthesia and park bench positioning with the head fixed in a Mayfield skull clamp. After ventral and caudal shoulder retraction, the head was rotated 60° opposite the HFS side with a slight lateral tilt of approximately 15° towards the floor to allow an optimal surgical corridor through the seventh nerve REZ as reported previously [56–58].

2.4. Transverse and sigmoid sinus projection

We first identified the landmarks, including the inion, the mastoid tip and notch, and a projection of the transverse sinus using Reid's baseline. We then performed a small (5 cm approximately) curvilinear rectosigmoid skin incision 3 cm behind the posterior ear (or 4.5 cm behind external acoustic meatus) over the transverse sinus projection. Next, we conducted a subperiosteal muscle dissection using sharp square periosteal elevators and monopolar (BovieTM) coagulation.

2.5. Microasterional craniectomy

The asterion is a landmark representing the junction of the lambdoid, parietomastoid, and occipitomastoid sutures. According to Rhoton's technique, we used the asterional burr-hole, as this method reduces the risk of lacerating the sinus complex in the posterior part of the parietomastoid suture, which is related to the transverse sinus's superior margin and its transition to the sigmoid sinus. From 1998 on, we used only one burr hole placed two centimeters below the asterion, two-thirds behind and one-third in front of the occipitomastoid suture. Under this technique, the micro-asterional keyhole craniectomy (2.5–3 cm) lays just below the inferior recess of the ipsilateral transverse sinus. Additionally, we applied wax vigorously over the edges to fill the defect when we opened mastoid air cells.

2.6. Dural opening

We performed a dural "C" shaped incision (1.5–2 cm) with the base at the transverse-sigmoid sinus junction to achieve the optimal dural angle exposure between tentorium and petrous surface [56–58]. Thus, when we correctly placed the microasterional craniectomy and correctly opened the dural, we did not need stitches to access both the CPA and infratentorial/supracerebellar corridors.

2.7. Intradural dissection

To amplify the operative field, we directed highly hydrated cottonoid patties rostrocaudally to allow drainage of the CSF. After sharp dissection of arachnoid membranes, we facilitated cisternal release by meticulous CSF depletion; then, the operative corridor is retractor-less opened using both the suction tube and bipolar electrocautery over soggy patties taking advantage of gravity. After optimal cerebellar relaxation, the cerebellum falls away from the petro-tentorial junction. Using the infrafloccular corridor, we could observe the pathway of the cisternal segment of the facial nerve from REZ to its bony entrance at the internal auditory canal.

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2.8. Microvascular decompression

After visualization of neurovascular conflicts, we confirmed the diagnosis, proceeding to move the offending vessels away using microsurgical dissectors on the left and off-bipolar on the right hand. After we identified the conflict zone, we applied one to three Teflon felt pledgets. When we observed no evidence of vascular contact on the seventh-nerve (n = 12 patients), instead of Teflon threads placement, we used very subtle compression over the REZ of the facial nerve using the off-bipolar for no more than five seconds. Finally, we closed the dura mater with a watertight technique.

2.9. Statistical analysis

We analyzed categorical variables using descriptive statistics (frequencies and percentages). For continuous variables, we used dispersion measures (means and SD). In addition, we used the student T-test to compare pre and postoperative status and outcomes between groups. Lastly, we performed a factorial regression analysis to identify preoperative risk factors.

3. Results

3.1. Demographics results

From May 1992 to December 2018, we collected 265 consecutive patients with diagnosis HFS admitted to the Department of Neurosurgery at NINN. Among them, 168 [63.4%] were women and 97 [36.6%] males. One-hundred forty-nine cases of HFS (56.2%) were left-sided, and one-hundred sixteen (43.8%) were right-side. Table 2 shows other additional demographic characteristics.

3.2. Preoperative clinical findings

Only four (1.5%) patients had a preoperative HB score of 2; the remaining two hundred sixty-one (98.5%) were grade 1. Concerning their HFS symptoms onset, two hundred thirty-seven (89.4%) typical HFS began in the lower eyelid progressing downwards to oral commissure, while twenty-eight atypical HFS (10.6%) had mouth muscles initially affected with spreading upwards. All the patients received an audiometric evaluation (n = 265); two hundred thirty-one (87.2%) of them had a normal result, while thirty-five (12.8%) were abnormal (Table 2). Because our institution is public and a national reference center, we performed brainstem auditory evoked potentials (BAEP) selectively in two hundred-seven patients that could afford the extra cost involved. BAEP was normal in one hundred seventy-two (83.1%) and abnormal in thirty-five (16.9%). Table 2 shows the summary of other essential preoperative clinical findings.

Table 2. Clinical characteristics and preoperative findings of the Study Patients.

Characteristics	Total (N = 265)	Free of HFS (n = 233)	Failure (n = 32)	P Value
Age (years)	50.4 ± 12.7	50.0 ± 12.2	53.63 ± 15.6	0.133
Sex				0.78
Male	97 (36.6%)	86 (88.7)	11 (11.3)	
Female	168 (63.4%)	147 (87.5)	21 (12.5)	
*Spasm side				*0.022
Right	116 (43.8)	108 (93.1)	8 (6.9)	
Left	149 (66.2)	125 (83.9)	24 (16.1)	
Type of Spams				0.124
Typical	237 (89.4)	211 (89.0)	26 (11.0)	
Atypical	28 (10.6)	22 (78.6)	6 (21.4)	
Botulinum Toxin				1.0
No	231 (87.2)	203 (87.9)	28 (12.1)	
Yes	34 (12.8)	30 (88.2)	4 (11.8)	
Previous Surgery				1.0
Yes	3 (1.1)	3 (100)	0 (0)	
No	262 (98.9)	230 (87.8)	32 (12.2)	
*BSAP				0.583
Normal	172 (64.9)	152 (88.4)	20 (11.6)	
Abnormal	35 (35.1)	30 (85.7)	5 (14.3)	
Audiometry				*0.044
Normal	231 (87.2)	207 (89.6)	24 (10.4)	
Abnormal	34 (12.8)	26 (76.5)	8 (23.5)	
Type of Approach				0.7
Asterional	247 (93.2)	216 (87.4)	31 (12.6)	
Jannetta	18 (6.8)	17 (94.4)	1 (0.6)	
Vessel in MRI				
No	115 (43.4)	104 (90.4)	11 (9.6)	
Yes	150 (56.6)	129 (86.0)	21 (14.0)	
Vessel				0.4
None	12 (4.5)	12 (100)	0 (0)	
SUCA	13 (4.9)	13 (100)	0 (0)	
AICA	188 (70.9)	165 (87.8)	23 (12.2)	
PICA	20 (7.5)	17 (85.0)	3 (15)	
Basilar	14 (5.3)	11 (78.6)	3 (21.4)	
More than one	18 (6.8)	15 (83.3)	3 (16.7)	
Type of Material				
Dacron	10 (3.8)	7 (70.0)	3 (30.0)	
Silastic	15 (5.7)	11 (73.3)	4 (26.7)	
Teflon	240 (90.6)	215 (89.6)	25 (10.4)	

*Statistically significant. Abbreviations: SD= Standard Deviation, IQR= Interquartile range, CBZ=Carbamazepine, PHT = phenytoin. * Tic convulsive defined as HFS concomitant with Trigeminal Neuralgia.

3.3. Preoperative MRI and neuro-radiological reports

All the two hundred sixty-five patients were evaluated with a 1.5 T MRI (Siemens) using T1/T2 weighted sequences to rule out other posterior fossa pathology rather than the suspected microvascular compression over the seventh nerve. Additionally, we performed fast imaging employing steady-state acquisition (FIESTA) sequence preoperatively to assess CSF within dural reflections of VII-VIII cranial nerves in all the patients. Brain-MRI was reported as normal in one hundred fifteen (43.4%) of the patients, and the offending vessel was presumptively identified in one hundred fifty (56.6%) of the patients (see Table 2).

3.4. Surgical results

A total of three hundred patients underwent MVDs (two-hundred sixty-five first-time surgery and thirty-five reinterventions) in two-hundred sixty-five patients in 26 years (Fig. 1).

3.5. Offending vessels and surgical findings

We identified a total of two hundred fifty-three offending vessels. The two main culprit vessels were AICA in one-hundred eighty-eight of the cases (70.9%), PICA in twenty (7.5%), the basilar artery in fourteen (5.3%), and SUCA in thirteen (4.9%). Compression by two different "loops" originated from different vessels was seen in eighteen (6.8%), while we found no offending vessel in twelve (4.5%) patients. We used Teflon two-hundred forty (90.6%) of the patients, which we consider the preferred material (after 1995) because of its ease of use, price, and maneuverability (see Table 3). Table 2 shows the remaining postoperative results.

3.6. Postoperative HFS-relief outcomes

In the whole two-hundred sixty-five patient cohort, we discontinued all conservative treatments after surgery. We performed a total of three hundred MVDs was performed, two-hundred sixty-five (88.3%) were first-time surgery; meanwhile, thirty-one (10.3%) patients needed a first reintervention, and among them, only four (1.3%) underwent a

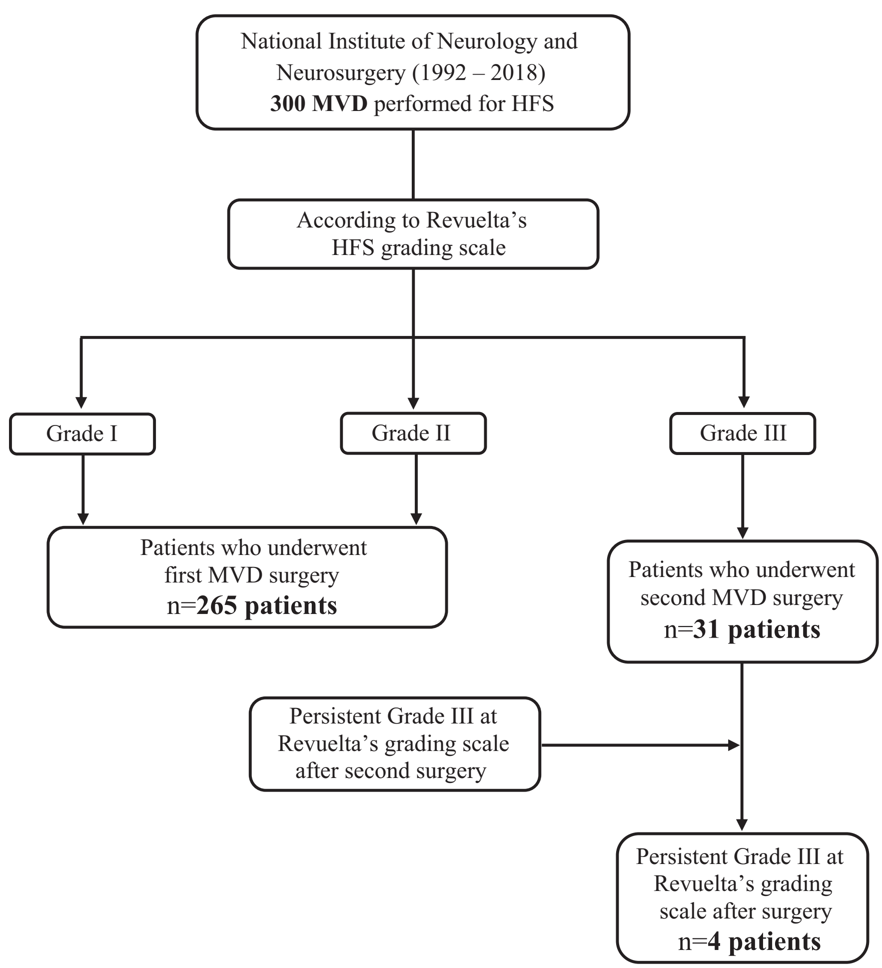

*Fig. 1. Flow Chart of patients who underwent MVD. *Grade IV was omitted due was applicable after six months of follow-up.*

Table 3. Postoperative complications.

Complications (n, %)	Transient	Permanent	Total
CN VI-related complication			
Diplopia	1 (0.3)	0 (0)	1 (0.3)
CN VII-related complication			
Facial palsy	36 (12)	9 (3)	45 (15)
CN VIII-related complication			
Hearing decrease	15 (5)	6 (2)	21 (7)
Deafness	0 (0)	2 (0.6)	2 (0.6)
Vertigo	13 (4.3)	0 (0)	13 (4.3)
Tinnitus	4 (1.3)	3 (1)	7 (2.3)
Others			
CSF leakage	7 (2.3)	0 (0)	7 (2.3)
Wound infection	5 (1.7)	0 (0)	5 (1.7)
Total*	81 (27)	20 (6.6)	101 (33.6)
HFS recurrence that diminished and had spontaneous relapse after one year follow-up	27 (9)	2 (0.6)	29 (9.6)

*Statistically significant. Abbretiatons: AICA = Anterior Inferior Cerebellar Artery, PICA= Posterior Inferior Cerebellar Artery, SUCA= Superior Cerebellar Artery.

second reintervention due to the persistence of HFS. For those who were re-operated, we saw no material migration either at first or second reintervention. Only three (1.1%) patients were previously surgically treated in other hospitals from the complete patient's sample. The immediate postoperative HFS relief according to Revuelta's HFS grading score results is displayed in Table 1. On the twelve patients whom a neurovascular conflict was not demonstrated, we obtained excellent results in 9 (75%), good in 2 (16.7%), and bad in only 1 (8.3%) patient after both the appliance of Teflon threads and very light compression with bipolar over seventh's nerve REZ for no more than 5 s.

3.7. Complications

Postoperative facial weakness was more common than hearing loss. Facial palsy was found in 45 (15%) at postoperative day 1 (HB5 and 4) with a recovery rate of 80% in the first 6-months of follow-up. We could not identify the offender vessel in 12 patients requiring light compression with the off-bipolar at seventh's nerve REZ; from them, four patients developed an HB 2, and one patient developed an HB 3 with hearing decrease with full recovery 6-months of follow up period. Hearing decrease was found in 21 patients (7%); among them, 15 patients had full hearing function recovery after 6-months of follow-up, six patients continued with a non-useful hearing by audiometry after a 1-year follow-up, and two (0.6%) with deafness. We had only one patient with diplopia who recovered spontaneously in 3 months after surgery. Table 3 demonstrates the information regarding other complications. We treated CSF leakages with external lumbar drainage showing complete resolution after the fifth day. Wound infections were entirely resolved with intravenous antibiotics demonstrating consecutive negative cultures within two weeks. Twenty-nine

Table 4. Logistic regression analysis for complications after 300 MVD for HFS.

Prognostic Factors	P Value	Odds Ratio	95% CI	
			Inferior Limit	Superior Limit
Age (years)	0.088			
Sex	.932	.973	.514	1.839
Spasm side	.387	1.305	.714	2.383
Type of Spams	.356	1.577	.600	4.147
Botulinic Toxin	.588	1.310	.493	3.478
Previous Surgery	1.000	.000	.000	.
BSAP	.185	1.859	.743	4.648
Audiometry	.803	.884	.335	2.330
**Type of Approach	.063	4.804	.921	25.060
Vessel	.54	1.698	1.202	2.399
Type of Material	.259	.483	.230	1.013
Culprit vessel in MRI*	0.003	.683	.352	1.325

*Statistically significant, ** Microasterional approach after 1998, and Retrosigmoid approach before 1998 were used.

patients (12.4%) presented recurrence of a grade IV HFS after a previous grade I or II within the initial six months to 2-years after the initial surgery. However, we performed no additional surgical intervention because spasms diminished spontaneously and attained quiescently. Table 4 shows the analysis of complications after the logistic regression; identifying a culprit vessel previous to surgery was the only factor statistically significant with a $p = 0.003$.

4. Discussion

The estimated incidence of HFS is 0.8 cases per 100,000 individuals with a 2:1 female preponderance ratio and a prevalence reported in 14.5 women per 100,000 cases and 7.4 males per 100 000 cases [4,6,11,25]. Since the first case of HFS described in the literature by F. Shültze in 1875, the hallmark of this entity has been the involuntary, paroxysmal, left-sided, and painless contractions of the muscles innervated by the facial nerve in middle-aged women [3,11,13,24,25].

Contrastingly to its unilateral nature (hemi = one side), there exist bilateral HFS cases [10,15,34,61,62] and HFS in patients under 30-year, as the so-called "young-onset HFS" [6,63,64]. In our study, the afflicted patients were predominantly females (63.4%) over the fourth and fifth decade of life, and with a slightly left-side apparition (56.2%), these results are consistent with the HFS current literature reported [3,4,7,9,11,46].

Typical HFS symptoms start on the lower eyelid and periorbital musculature but later involve the ipsilateral facial, perioral, and platysma muscles over months to years [1,11]. On the other hand, patients with atypical syndrome start instead on the lower half of the face [11,12,15]. Like other series, we found the "typical" syndrome onset as the most common HFS in two-hundred thirty-seven (89.4%), while finding "atypical" syndrome in twenty-eight (10.6%). We found only twelve (4.5%) patients with "tic convulsif" or "tic dolorous," as the initially Cushing's description at 1920 when HFS is coexisting with TN [18,59].

Although in practice, the underlying HFS etiology is the nerve attrition due to an atypically aberrant blood vessel, two main theories explain the pathophysiology of HFS. The "peripheral" hypothesis stands that the neurovascular interface triggers ephaptic and ectopic action potentials from the locally demyelinated facial nerve fibers by surrounding arterial loops, which compresses the facial nerve within or close to the REZ [3–5,23,34]. The opposite "central" hypothesis stands that hyperexcitability arises from the facial motor nucleus in the brainstem [3]. HFS diagnosis is easy to ascertain clinically by simple observation of the patient's face; however, it is frequently confused with other facial movement disorders. Neurodiagnostic studies are rarely helpful in HFS. Recent evidence suggests that MRI should be performed when possible using a 3T magnet due to signal-to-noise and contrast-to-noise ratios better at 3T than lower field strengths [35]. However, neuroimaging studies have also found nerve conflicts at VII/VIII nerve complex in asymptomatic patients [36,37]. The anatomic conspicuity of the posterior fossa and the poor delineation of cranial nerves on image studies complicate small vessels' assessment. Surprisingly, the interobserver discrepancy and differences between image studies concerning the conflict vessels reported preoperatively in HFS on MRI studies correlate purely with the actual vessels seen at surgery compressing the VII nerve [5]. From one hundred fifty patients' studies with an abnormal MRI, we found that ninety-eight (37%) of them reported a non-specific vascular loop, and forty-seven (17.7%) reported a dolichoectatic basilar artery; while five (1.9%) only reported an "abnormal MRI." MRI-angiography may demonstrate the vascular features around the root entry zone [11]. Although a CT or MRI screening imaging study may not be justified in all cases of HFS, it is prudent to employ these diagnostic studies in all atypical cases to rule out tumoral pathology rather than an accurate compression over a specified vessel.

Our experience with these patients has led us to think that long-standing disease and delay in surgical treatment frequently lead to social isolation. As the diagnosis can be difficult, a psychogenic stimulus such as emotional stress, repetitive face movements, and even speaking can elicit and trigger spasms, helping in differentiate them from other facial movements disorders such as blepharospasm, oromandibular dystonia, facial tic, hemimasticatory spasm, myokymia, and facial myorhythmia [4,10,19,27]. HFS, along with palatal myoclonus, is the only two-movement disorder that persists during sleep [2,20–23].

Rather than surgery, other therapeutic options consider oral medications, acupuncture, and botulinum toxin type A injections [9,24,27]. The subcutaneous injections with botulinum toxin type A on the facial affected muscles produce complete or almost complete relief of symptoms in 76–100% of patients [28,65]; however, the improvement is only temporary (mean duration, 3–6 months). In addition, despite the effectiveness of botulinum toxin injections can be maintained for years to alleviate the symptoms of HFS, it represents a less cost-effective treatment due to dosage that may need to be gradually increased to achieve its desired effect [9,28]. In this series, we found the main alternative conservative treatment received was botulinum toxin type A in thirty-four (12.8) patients, followed by CBZ and PHT in twenty-one (7.9%). Furthermore, we saw a mean of three years delay before MVD as definitive treatment among those who received botulinum toxin type A.

In Mexico, applying a single botulinum toxin injection for HFS cost between 5500 and 7300 Mexican pesos (275–365 US Dollars). This cost includes medical fees, botulinum toxin bottle (AllerganTM) at each session. Nevertheless, one patient with HFS needs approximately four sessions, summing a total of 22,000–29,200 Mexican pesos (1100–1460 US Dollars) for optimal relief for three months. On the other side, in our hospital, the mean individual payment for MVD for HFS is 3000 Mexican pesos (150 USD), including surgery, doctor fees, and in-hospital care for three postoperative days.

The only curative treatment and HFS long-term control that treats the cause of HFS has been the nerve decompression of the culprit's vessel on REZ [17,38,45]. This zone, also called the Obersteiner-Redlich zone, corresponds with a transitional zone between central and peripheral myelin. HFS has excellent clinical results after MVD when performed by a neurosurgeon who has experience in the nuances of the operative procedure; however, newer MVD technique has been strengthened over time by the endoscope integration in the so-called endoscope-assisted (EA) surgery. When combined, EA procedures bring inherent endoscope's advantage in "looking around the corner." Other advantages in using EA are avoidance of cerebellar retraction in patients with complicated or abnormal posterior fossa anatomy where the microscope's view alone limits identification of neurovascular conflicts [66,67].

In the present series, we found the anterior inferior cerebellar artery (AICA) as the primary culprit vessel in one hundred eighty-eight (70.9%) [3,9,12,43,68]; however, others have reported the posterior inferior cerebellar artery (PICA) as the most common vessel responsible [17,40,44,45,69] (PICA twenty (7.5%) in our series). More rarely, vein compressions as etiology for HFS have also been described [69,70]. Interestingly, although most nerve–vascular complexes responsible for HFS are either rostrocaudally or ventrocaudal at the REZ or brainstem, a blood vessel on the posterior or rostral side of the nerve could cause the atypical HFS; however, these findings were not statistically significant in this case series.

Sindou et al., in 2018 reported a variety of grading scales for assessing the outcome after MVD for HFS [52]; however, returning to the patient's self-assessed previous everyday life is the best indicator that impacts the final outcome. Therefore, the patient's HFS relief appreciation is the best indicator that the surgeon could achieve (RRG).

The overall consensus for reoperation in recurrent HFS after MVD has been set to 12 months [52]. However, the senior surgeon's opinion (RRG) is that patients with recurrent symptoms in the first four days after surgery require immediate exploration, and those with later recurrence without facial paresis are likely to improve within the next six months to 2 years. Although HFS is painless and non-life-threatening, HFS affects facial appearance; the cosmetic and aesthetic discomfort becomes socially and frequently economically disabling [46]. In severe cases, the facial disfigurement generates high anxiety levels with potentially psychiatric complications that could directly impact self-image and satisfaction [9]; this severe condition requires timely diagnosis and therapy [24]. In the MVD, as in the rest of Neurosurgical procedures, high precision preoperative planning is mandatory.

This series is the largest to date on a Hispanic population. In high-volume centers with experienced Neurosurgeons, the MVD for HFS through a microasterional craniectomy approach constitutes a reliable surgical treatment at which it is possible to achieve optimal exposure of the central aspect of the CPA. The main challenge is the limited microsurgical working space to achieve a successful decompression and optimal brain stem structures [45]. In addition, the microasterional craniectomy approach is minimally invasive, nondestructive, and achieves good long-term results with minor morbidity.

This study has two limitations. First, we did not use intraoperative EMG and BAEP due to the cost involved. Electrophysiological monitoring is a valuable tool in MVD surgeries, such as monitoring the abnormal muscle response (AMR) while evaluating the offending vessels and ensuring adequate decompression, or by BAEP monitoring to reduce the incidence of hearing impairment [71]. Unfortunately, this circumstance prevented us from observing an association between neurophysiological studies and postoperative deficits. Second, the inherent limitations of retrospective, single-center investigations. The main delay in receiving surgical treatment was over-population at our institution and the surgical cost involved. We did not compare MVD effectiveness over patients only treated with botulinum toxin in a control group. Extensive studies are lacking that compare the possible therapeutic options in randomized and controlled trials. Despite these limitations, we recommend that surgery be deliberately decided, especially in the early stages, and immediate reoperation in spasm relapse within 1-week of surgery.

5. Conclusions

Due to the recent technological advancements in microsurgery, extensive craniotomies have been replaced by less invasive keyhole craniotomies. We have found that the patients' age, gender, pathology side, and the time from onset of symptoms are non-related factors in achieving a good outcome after MVD in HFS after surgical treatment.

The use of alternative treatments, different from surgical, tends to worsen HFS over a variable period. While non-life-threatening, HFS can significantly affect the quality of life.

In well-trained hands, MVD through a retractor-less microasterional approach is an effective and safe technique for treating HFS; in addition, MVD is the only curative treatment for HFS. Therefore, failure to HFS improvement after 1-week of MVD warrants immediate reoperation.

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with literature review. Parkinsonism Relat Disord 2008;14(2): 154–6. https://doi.org/10.1016/j.parkreldis.2007.06.001.
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Reviewer Comment 1:

Microvascular Decompression for Hemifacial Spasm: Surgical Technical Nuances and Results After 300 Microvascular Decompression Surgeries
This paper shows the outstanding results of case series of microvascular decompression for hemifacial spasms. The authors also report the demographic characteristics of the patients and the most frequent etiology causing the compression. This referral center shows a significant concentration of these patients, which determined a large sample of collected cases.

The author also describes the technique dominated by this group of microasterional craniotomy, which provides a minimally invasive approach to the middle cerebellar complex and excellent exposure to the structures involved.

The results obtained in improving spasms are satisfactory and preserve facial and auditory function. This group recommends performing a new intervention if there is no improvement in the spasm in the first week after surgery. On the opposite, other studies in similar patients suggest waiting longer. It will be worthwhile to conduct prospective and comparative studies between various hospital centers to contrast the results.

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ARCHIVES OF NEUROSURGERY

Archives of Neurosurgery

Volume 1 | Issue 2 Article 3

2020

Aneurysmal subarachnoid hemorrhage and acute subdural hematoma, neurosurgical and endovascular rescue. Case report.

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ARCHIVES OF NEUROSURGERY REVISTA DE DIVULGACIÓN CIENTÍFICA DE LA SOCIEDAD MEXICANA DE CIRUGÍA NEUROLÓGICA A.C., Año 1, No.2 (enero a junio 2022) es una publicación cuatrimestral editada por la Sociedad Mexicana de Cirugía Neurológica A.C., Miami 47, Nápoles, Benito Juárez, 03810 Ciudad de México, CDMX, Tel 52 (55) 5543 0013, https://www.ansjournal.org. Editor: Fiacro Jiménez Ponce. Reserva de Derechos al Uso Exclusivo No. 04-2023-051212055700-102, ISSN: En trámite, ambos otorgados por el Instituto Nacional del Derecho de Autor. Responsable de la última actualización de este número Fiacro Jiménez Ponce, Miami 47, Nápoles, Benito Juárez, 03810 Ciudad de México, CDMX, fecha de última modificación 22 de junio del 2022.

Aneurysmal subarachnoid hemorrhage and acute subdural hematoma, neurosurgical and endovascular rescue. Case report.

Abstract

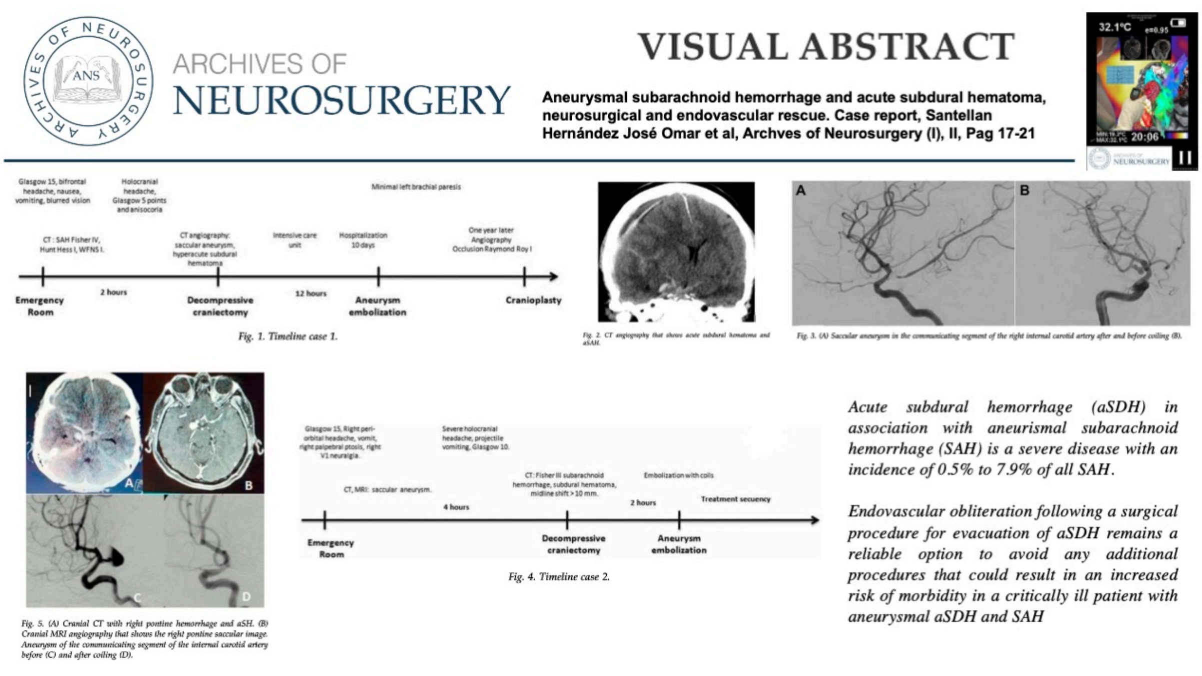
Introduction: Acute subdural hemorrhage (aSDH) in association with aneurismal subarachnoid hemorrhage (SAH) is a severe disease with an incidence of 0.5% to 7.9% of all SAH. Due to the rarity of aneurysmal aSDH, it remains difficult to define a comprehensive management protocol. In this case review, following the CARE guidelines, we show the hybrid management of this pathology to know the importance of using different types of neurosurgical treatments in case of two severe diseases in critical patients.

We present two patients who developed sudden onset cephalea and neurological impairment secondary to aneurysmal subarachnoid hemorrhage associated with acute subdural hematoma. These cases required emergency decompressive craniectomy and aneurysm embolization with coils that have a favorable outcome.

In patients with massive and rapidly fatal subdural hemorrhage, emergency craniotomy with hematoma evacuation and immediate brain decompression before definitive aneurysm surgery has shown to be a good treatment option with excellent survival outcomes.

Conclusion: Endovascular obliteration following a surgical procedure for evacuation of aSDH remains a reliable option to avoid any additional procedures that could result in an increased risk of morbidity in a critically ill patient with aneurysmal aSDH and SAH.

Visual Abstract



Keywords

subarachnoid hemorrhage, subdural hematoma, endovascular rescue, case report.

Authors

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CASE REPORT

Aneurysmal Subarachnoid Hemorrhage and Acute Subdural Hematoma, Neurosurgical and Endovascular Rescue. Case Report

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Abstract

Introduction: **Acute subdural hemorrhage (aSDH) in association with aneurismal subarachnoid hemorrhage (SAH) is a severe disease with an incidence of 0.5%−7.9% of all SAH. Due to the rarity of aneurysmal aSDH, it remains difficult to define a comprehensive management protocol. In this case review, following the CARE guidelines, we show the hybrid management of this pathology to know the importance of using different types of neurosurgical treatments in case of two severe diseases in critical patients.**

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In patients with massive and rapidly fatal subdural hemorrhage, emergency craniotomy with hematoma evacuation and immediate brain decompression before definitive aneurysm surgery has shown to be a good treatment option with excellent survival outcomes.

Conclusion: **Endovascular obliteration following a surgical procedure for evacuation of aSDH remains a reliable option to avoid any additional procedures that could result in an increased risk of morbidity in a critically ill patient with aneurysmal aSDH and SAH.**

Keywords: Subarachnoid hemorrhage, Subdural hematoma, Endovascular rescue, Case report

1. Introduction

Acute subdural hemorrhage (aSDH) associated with aneurismal subarachnoid hemorrhage (SAH) is a severe disease involving 0.5%−7.9% of all SAH case [1] Due to the rarity of aneurysmal aSDH, it remains challenging to define a comprehensive management protocol. Patients with a Glasgow Coma Scale score below eleven points at admission or a rapidly deteriorating level of consciousness, urgent surgical decompression, and immediate aneurysm obliteration usually result in a favorable outcome. Nevertheless, endovascular obliteration after the evacuation of an aSDH remains a reliable option for those cases where aneurysm clipping was not feasible in the initial procedure [1]. With the present cases, we aim to demonstrate the hybrid management for this pathology.

2. Case report 1 (Fig. 1)

A 50 years old female with a history of recent headaches presented with sudden onset of severe bifrontal headache associated with postural change, nausea, and vomiting; at the arrival to the emergency service, the main symptoms were general weakness sensation and diaphoresis, and blurred vision..

Physical examination revealed a Glasgow Coma Scale score of 15 points; the neurological exam was normal except for decreased venous pulses in the

Received 25 June 2020; revised 4 September 2020; accepted 15 January 2021.
Available online ▪ ▪ ▪

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ocular fundus, generalized hyperreflexia, and a slightly stiff neck. The computer tomography scan (CT-scan) showed subarachnoid hemorrhage classified as Fisher IV, Hunt Hess I, and World federation Neurosurgeons Society (WFNS) I. Sixty minutes later, a new episode of holocranial headache followed by a decrease in Glasgow Coma Scale score to 5 points and anisocoria with the need for orotracheal intubation. CT angiography found a saccular aneurysm in the communicating segment of the right internal carotid artery and a 15 mm thickness hyperacute right frontotemporal subdural hematoma, right uncus herniation, and 12 mm midline shift (Fig. 2). We performed an emergency decompressive craniectomy to evacuate the hematoma 2 h since the beginning of symptoms; clipping of the aneurysm was not possible due to hemodynamic instability and severe cerebral edema. After 12 hours in the intensive care unit, we performed a cerebral angiography and aneurysm embolization with coils (Fig. 3). Finally, the patient was stable and showed improvement and left the hospital after ten days with minimal left brachial paresis. One year later, the follow-up angiography showed total aneurism occlusion (Raymond Roy Class I). Lastly, we performed a cranioplasty twelve months after the initial decompressive craniectomy.

3. Case report 2 (Fig. 4)

A 47-year-old female with a history of hypertension and headaches for over three years had a sudden onset of severe headache in the right periorbita associated with vomiting. Upon arrival in the emergency room, she demonstrated a score of 15 points on the Glasgow Coma Scale, right palpebral ptosis, and right V1 neuralgia. CT scan showed a right pontine saccular image compared to magnetic resonance image (MRI) angiography, where it appeared to be an aneurysm of the communicating segment of the internal carotid artery. Clinical features progressed to severe holocranial headache, projectile vomiting, and neurological deterioration with a Glasgow Coma Scale score of ten and mydriasis. In addition, a new CT scan showed Fisher III subarachnoid hemorrhage and right frontotemporal subdural hematoma with midline shift >10 mm. Therefore, we performed a decompressive craniectomy in the following 4 h to evacuate the hematoma. However, it was impossible to access the aneurysm because of the severe brain edema, and we established treatment with endovascular therapy for aneurysm embolization in a second stage (Fig. 5).

Abbreviations

SDH	Subdural hemorrhage
aSDH	acute subdural hemorrhage
CT	computer tomography
WFNS	World federation neurosurgeons society
ACA	Anterior cerebral artery
ACoA	Anterior communicating artery
ICA	internal carotid artery
MCA	Middle cerebral artery
MRI	magnetic resonance image.

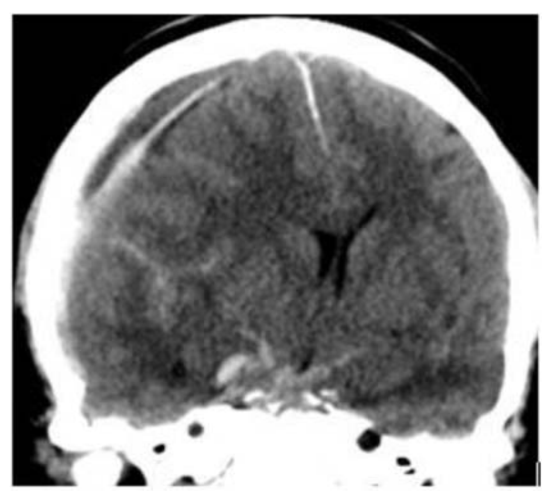

Fig. 2. CT angiography that shows acute subdural hematoma and aSAH.

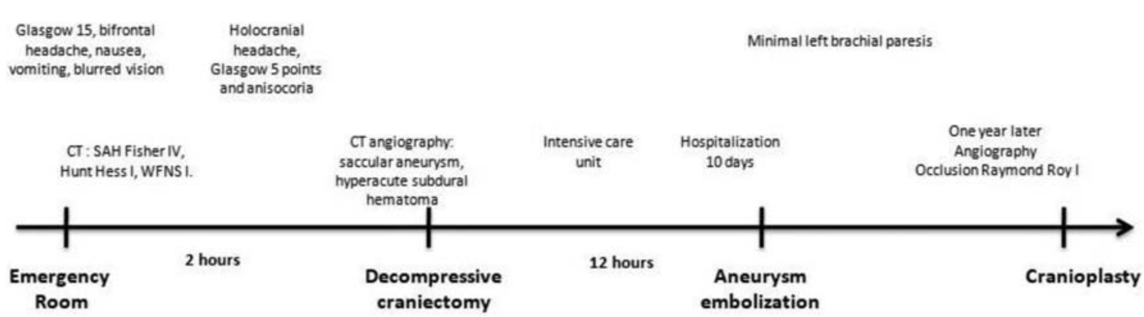

Fig. 1. Timeline case 1.

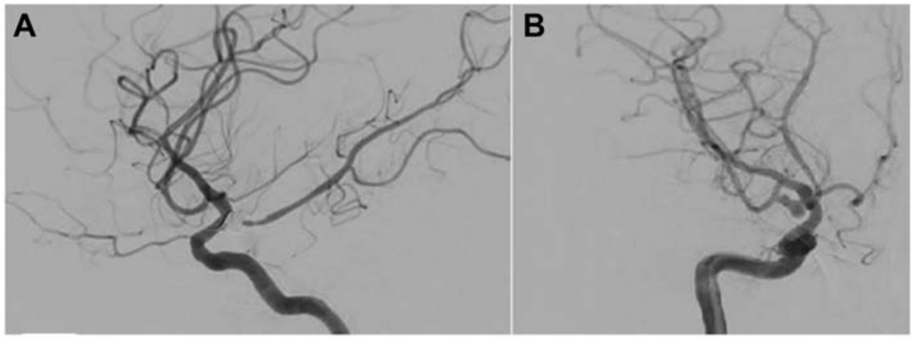

Fig. 3. (A) Saccular aneurysm in the communicating segment of the right internal carotid artery after and before coiling (B).

4. Discussion

Acute SDH resulting from the rupture of an aneurysm was first reported in 1855 described as a severe disease that occurs in 0.5%−7.9% of all subarachnoid hemorrhages [1]. A third of the patients who suffer a subarachnoid hemorrhage due to a saccular aneurysm rupture presents an intracranial hematoma [1]. However, the combination of a ruptured aneurysm and the spontaneous acute subdural hematoma is undoubtedly rare [1].

Since the first report in 1934, many cases of spontaneous aSDH have been reported [1]. The leading causes included aneurysmal bleeding, perisylvian cortical arteries rupture, tumors, and neoplastic diseases [1].

There exist four mechanisms by which blood can reach the subdural space from a ruptured aneurysm [2]. 1) Successive small hemorrhages allow the development of adhesions toward the subdural space where the final rupture occurs [2]. 2) Abrupt rupture of the arachnoid membrane by the rapid increase in pressure from the ruptured aneurysm [2]. 3) A massive hemorrhage ruptures the cortex and lacerates the arachnoid membrane [2]. 4) An aneurysm in the part of the carotid within the subdural space ruptures and directly causes aSDH [2].

Clarke and Walton classified patients into three groups based on the size of the subdural clot and the clinical course: Group I is defined by massive and rapidly fatal intracranial hemorrhage, Group II comprises an insignificant quantity of subdural blood and is not fatal, and Group III involving significant subdural hematoma, which is not rapidly fatal [2].

In those cases where the origin of the aSDH is indeterminate but occurs in association with subarachnoid hemorrhage, intracranial hypertension, intracortical clot, xanthochromic, or bloody ventricular fluid; a cerebral angiography is mandatory [3].

An aneurysm at any site can cause aSDH upon rupture [3]; nevertheless, those occurring from the rupture of the distal Anterior cerebral artery (ACA) or Anterior communicating artery (AcomA) aneurysms are rare, while those in the internal carotid artery (ICA) and middle cerebral artery (MCA) aneurysms are common [3]. Reynolds and Shaw found that the anterior communicating artery aneurysms were the most common origin for subdural hematomas [3]. It deserves to mention that vertebrobasilar aneurysms are separated by a thick barrier called the Liliequist membrane, which might hinder the development of acute SDH [3].

Risk factors to be considered for increased risk of co-occurrence of aSDH with aneurysmatic subarachnoid hemorrhage are older age, aneurysm at the posterior communicating artery, sentinel headache, and intracranial hemorrhage.

It is suggested that the presence of an aneurysmal aSDH depends on the aneurysm anatomy and perianeurysmal environment [4]. For example, interaction with adjacent structures may occur; when an aneurysm protrudes into the basal cisterns and interacts mainly with the basal arachnoid membrane, aneurysm rupture might result in aneurysm rupture of the arachnoid membrane with a subsequent aSDH [4].

Due to the rarity of aneurysmal aSDH, it remains challenging to define a comprehensive management protocol [5]. However, patients with a poor neurological exam at admission and rapidly deteriorating levels of consciousness, urgent surgical decompression, and immediate aneurysm obliteration result in a favorable outcome [5].

Patients presenting with both SAH and aSDH have poor admission grades and prognoses [6]. The literature reports a 5% incidence of massive subdural hematoma [6]. These patients with signs of cerebral herniation underwent CT angiography and surgical clipping with the simultaneous evacuation of the space-occupying hematoma [6]. A decompressive craniectomy was added for those with brain swelling, followed by cranioplasty more than two months after in survivors [6].

The angiography must be performed before the operation if possible. Angiography must be

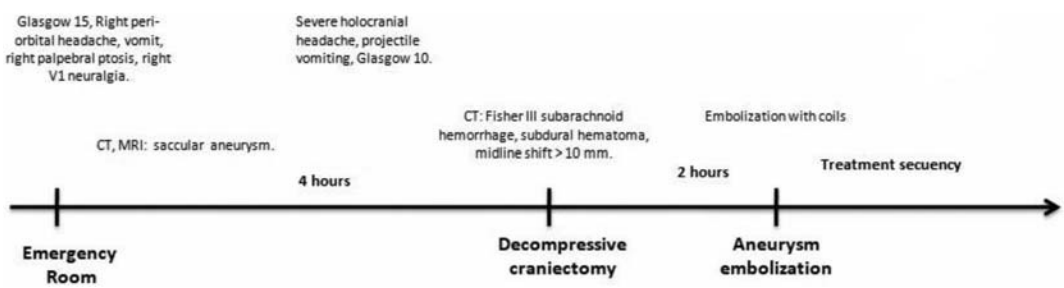

Fig. 4. Timeline case 2.

performed before the operation whenever possible, considering endovascular embolization in the same stage. However, diagnostic-therapeutic angiography can be delayed to the most immediately possible postoperative stage in those cases requiring urgent surgery for hematoma evacuation because of life-thretening neurological compromise [6].

Special consideration for coil embolization should be given when surgery is impossible or risky. For example, a poor Hunt-Hess grade or evidence of significant brain swelling without a mass lesion may increase the risk of surgical retraction but influences lesser the difficulty of coil embolization treatment [7]. According to the American Heart Association, the adverse outcomes, defined as discharge to a nursing home or rehabilitation center, is less frequent in those treated with endovascular therapy (10% versus 25% with surgery), as is the risk of in-hospital death (0.5% versus 3.5%) [7].

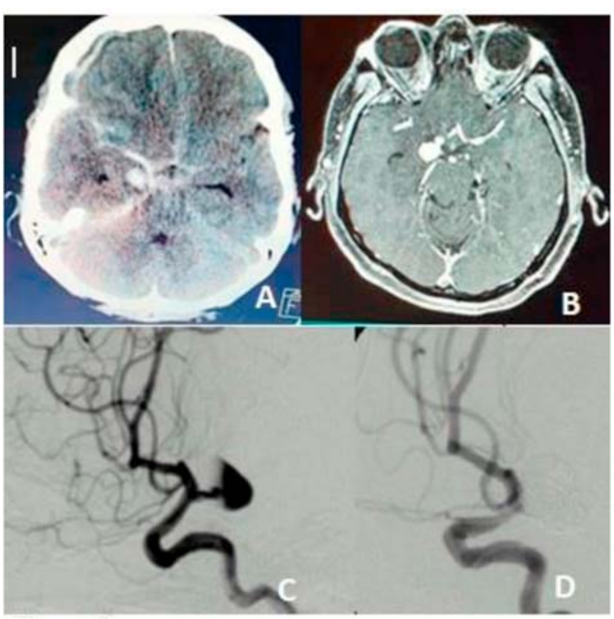

Fig. 5. (A) Cranial CT with right pontine hemorrhage and aSH. (B) Cranial MRI angiography that shows the right pontine saccular image. Aneurysm of the communicating segment of the internal carotid artery before (C) and after coiling (D).

Despite a deplorable clinical condition on admission, recovery with the only minor deficit is possible, as Westermaier et al. [8] showed in five of eight patients treated with endovascular coiling, obtaining a Glasgow Outcome Score between 3 and 5 points.

Mydriasis and Aneurysmal aSDH are described among the factors predicting poor prognosis, compared to those who suffered aneurysmal aSDH without SAH [6].

The CT appearance of a subdural hematoma secondary to a ruptured intracranial aneurysm may give no clue to the true origin, but CT angiography has an acceptable sensitivity. The reasons are obvious: speed of diagnosis, the safety of the procedure, and high diagnostic accuracy for acute intracranial hematomas and aneurysm identified [6].

5. Conclusion

Endovascular obliteration after a surgical procedure for evacuation of aSDH remains an excellent option to avoid an additional morbidity procedure in a critically patient who presents aneurysmal aSDH and SAH.

Authorship

- José Omar Santellán Hernández-the conception and design of the study, or acquisition of data, or analysis and interpretation of data.
- José Ramón Aguilar Calderón-drafting the article or revising it critically for important intellectual content.
- Abraham Ibarra de la Torre-the conception and design of the study, or acquisition of data, or analysis and interpretation of data.
- Ulises García Gonzalez-final approval of the version to be submitted.

Publication Comment:

In this article, the authors presented two cases of aneurysmal rupture associated with an acute subdural hematoma. Each pathology represents an urgency, given its associated high morbidity and mortality, and even more combined.

There are several treatment alternatives to treat both pathologies:

Craniotomy or craniectomy with subdural hematoma evacuation and aneurysm exclusion by clipping in the same surgical event.

Craniotomy or craniectomy with the hematoma evacuation excluding the aneurysm by endovascular technique in two events.

The authors present two adequately resolved cases that were treated by craniectomy and endovascular therapy with excellent results. They justified its management due to the significant cerebral edema that makes the microsurgical approach difficult in these cases. When the cerebral edema is not so severe, and the hemodynamic conditions of the patient allow it, it is possible, in addition to draining the hematoma, to resolve the aneurysm by microsurgery, both in the same surgical time. However, such management is sometimes not possible if cerebral edema prevents access to the aneurysm or if the patient's neurological and hemodynamic conditions do not allow it. Both alternatives are suitable.

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Informed consent

Patients have informed consent of all diagnostic and therapeutic procedures according to the policies of Hospital Central Sur de Alta Especialidad.

Conflicts of interest

The authors declare no conflict of interest.

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ARCHIVES OF NEUROSURGERY

Archives of Neurosurgery

Volume 1 | Issue 2 Article 4

2020

The scientific divulgation in neurosurgery.

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ARCHIVES OF NEUROSURGERY REVISTA DE DIVULGACIÓN CIENTÍFICA DE LA SOCIEDAD MEXICANA DE CIRUGÍA NEUROLÓGICA A.C., Año 1, No.2 (enero a junio 2022) es una publicación cuatrimestral editada por la Sociedad Mexicana de Cirugía Neurológica A.C., Miami 47, Nápoles, Benito Juárez, 03810 Ciudad de México, CDMX, Tel 52 (55) 5543 0013, https://www.ansjournal.org. Editor: Fiacro Jiménez Ponce. Reserva de Derechos al Uso Exclusivo No. 04-2023-051212055700-102, ISSN: En trámite, ambos otorgados por el Instituto Nacional del Derecho de Autor. Responsable de la última actualización de este número Fiacro Jiménez Ponce, Miami 47, Nápoles, Benito Juárez, 03810 Ciudad de México, CDMX, fecha de última modificación 22 de junio del 2022.

The scientific divulgation in neurosurgery.

Abstract

The communication of scientific findings in a young discipline in the evolution of knowledge about the human nervous system, has had a consistent and significant advance. This interdisciplinary and multidisciplinary vision has been a fundamental educational axis in the development of neurosurgery in terms of innovation, scientific progress, technological development and quality of patient care. It is therefore essential that scientific writing and communication channels continue to preserve these quality standards, to validate without bias and with certainty, the value and strength of the advances of neurosurgery as a science.

Visual Abstract

Keywords

Journal impact factor, Medical education, Medical ethics, Neurosurgery, Publication, Research methods.

The Scientific Divulgation in Neurosurgery

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Abstract

The communication of scientific findings in the evolution of knowledge in a young discipline about the human nervous system has had a consistent and significant advance. This inters and multidisciplinary vision has been a fundamental educational axis in the development of neurosurgery in terms of innovation, scientific progress, technological development, and quality of patient care. Therefore, scientific writing and communication channels must continue to preserve these quality standards, validate without bias, and with certainty the value and strength of neurosurgery advances as a discipline.

Keywords: Journal impact factor, Medical education, Medical ethics, Neurosurgery, Publication, Research methods

The communication of scientific findings in the evolution of knowledge in a young discipline about the human nervous system has had a consistent and significant advance, especially in the last 120 years. As the functional role of the brain and its peripheral connections (the neuronal theory) were identified in terms of electrophysiological and biochemical implications, a series of questions and challenges were generated, which psychiatry initially addressed almost on the same scale as neurology. Later on, clinical neurology had to face the frontier of surgery as a challenge to advance, resulting in neurosurgery's birth as a field of knowledge.

The first formal schools for neurosurgical training emerged in Europe with a fully anatomical approach based on the clinical principles of neurological examination. In this way, the basic principles on which many surgical procedures are based were developed and still prevail in medical training and education.

The evolution in the American continent, both in the North and in the southern cone, was decisive to rethink the teaching models, which by that date already postulated a specific curriculum design involving basic sciences, clinical sciences, neuropathology, and of course, neurosurgical practice.

The multidisciplinary vision of other scientific branches enriched the surgical practice by expanding its range of possibilities. This vision is best exemplified by the collaboration of the mathematician Robert Henry Clarke with Sir Victor Horsley to define a prototype for stereotaxy, as well as that of Ivan Pavlov and Harvey Cushing to understand the behavioral implications of the human brain, and Santiago Ramon y Cajal and Charles Scott Sherrington to define neuronal theory and the implications on synapses, to point out some virtuous associations [1].

This inters and multidisciplinary vision has been a fundamental educational axis in the development of neurosurgery in terms of innovation, scientific progress, technological development, and quality of patient care.

In this scenario, scientific dissemination has always been present in different formats. While during the period of the Maecenas, it was a transfer of knowledge in a pragmatical and observational nature by direct experience, the scientific rigor proposed for neurosurgery demanded the highest standards in its discipline and training processes, as well as a progressive refinement in the way of communicating and disseminating scientific information. In this way, we gradually moved from descriptive anecdotal experiences to more structured methodological proposals that promoted the conversion of information into knowledge and supported the principles of scientific

Received 20 July 2020; revised 14 March 2021; accepted 19 July 2021.
Available online ■ ■ ■

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ISSN-Pending. Published by Mexican Society of Neurological Surgery (Sociedad Mexicana de Cirugía Neurológica A.C.).

Archives of Neurosurgery
2021;xx(xx):1–4

communication. The surgical observations and expert opinions helped to consolidate a key route for the development of neurosurgery.

After the First World War, on August 31st, 1931, the first International Neurological Congress was held in the municipal theatre of the city of Bern, Switzerland. Predominantly constituted by neurologists and psychiatrists, in this event appeared the first conferences of those formerly trained as neurosurgeons, as it was the case of Clovis Vincent (Paris, France), Percival Bayley (USA), Wilder Penfield (Canada), highlighting a particular interest in the presentation of Harvey Cushing with his lecture "two thousand brain tumors" [2–4].

The description of a methodology in presenting morbidity and mortality, aseptic guidelines, anesthetic strategies, and formal education in neurological surgery was vital to open the formative scenario of neurosurgery in the world.

Although the methodological approach is now one of the primary subjects in education, greater formality and better understanding is required to consolidate an academic society that disseminates science with the support of different computer tools for design, statistics, reference management, and scientific rigidity.

It is, therefore, essential that scientific writing and communication channels continue to preserve these quality standards, to validate with certainty free of bias the value and strength of the advances of neurosurgery as a discipline [5].

A fundamental principle for scientific communication is "having something important to say"; not only for innovation but for the significance in improving decision-making on a particular topic or technique for state of the art. Therefore, it is essential to identify compliance with the minimum information required under a specific methodological argument making simple questions such as what, how, where, when, and why.

Due to the lack of an appropriate methodological design, there are significant findings that lose interest for the scientific community and are destined to remain in the hidden drawer of "anecdotes" as a personal casuistry; however, their level of scientific evidence is limited.

This level of substantive evidence is one of the results of efficient communication in any branch of science. The most accurate methodological designs are those derived from comparative studies, with controls, blinded, randomized, multicenter, evaluated anonymously by expert peers, and without conflict of interest. From these strategies emanate the "gold-standards," which can contrast with clinical guidelines, recommendations, or personal experiences that have lower evidence quality for decision making, therefore exist various systems to grade evidence to discriminate faster between the best evidence among the different study types, nevertheless, these grading systems should always be used with caution and proper interpretation [6–8] (Table 1).

A good article or review paper can benefit both the author and those interested in their particular area. Within these benefits, three aspects stand out: 1) literature review, writing, and creating an article commits the author to make a thorough examination of the published literature, contributing to the knowledge, experience, and mastery in the topics of interest; 2) pedagogy and teaching, depending on the style of each author, there may be a combination of topics or strategies to facilitate or express the main ideas, which, in many occasions may not be familiar to the reader, seeking to condense complex information effectively. 3) Fomenting the habit of writing, which has become a necessity in neurosurgery in different academic and clinical positions, contributing to the writer's professional development [9,10] (Table 2).

Currently, there are search systems to identify the best option to publish, according to the disciplinary content of the topic, its methodological design or level of evidence, significance, and novelty in the scientific literature. Generally, the summary of the article is presented, and the search system can display the options of viable journals, considering the impact, the rejection rate, and the possibilities of acceptance according to their editorial ranks.

These tools have been incorporated to make publishing efficient and timely, given that getting updated is expeditiously is fundamental.

However, it is always advisable to review carefully and follow the author's instructions of a particular journal, avoiding rejections due to format errors provided that information is already online through specific editorial platforms.

Therefore, methodological designs must be robust to completely expose the actual scientific value of relevant findings in basic science, clinical data, neurosurgical technique, or translational research in neurosciences. In addition, this strategy will be helpful to prevent any bias by developing blinded and randomized studies.

Abbreviations

RCT	Randomized controlled trial

Table 1. Levels of Evidence in differents studies [7,8].

	Prevalence Studies	Screening Studies	Diagnostic Studies	Prognostic Studies	Treatment Benefit Studies	Treatment Harms Studies
Level I	Local and current surveys or censuses	Systematic review of randomized trials	Systematic review of cross sectional studies	Systematic review of cohort studies	Systematic review of randomized trials or N-of-1 trials	Systematic review of randomized trials or case-control N-of-1 trial
Level II	Systematic Reviews (matching with local circumstances)	Randomized trial	Individual cross sectional studies	Inception cohort studies	Randomized trial Observational study with dramatic effect	Individual randomized trial
Level III	Local non-random sample	Non -randomized controlled cohort Follow-up study	Non-consecutive studies. Studies without consistently applied standards	Cohort study Control arm of randomized trial	Non-randomized controlled cohort Follow-up study	Non-randomized controlled cohort Follow-up study Post-marketing surveillance
Level IV	Case-series	Case-series Case-control Historically controlled studies	Case-control	Case-series Case-control Poor quality prognostic cohort	Case-series Case-control Historically controlled studies	Case-series Case-control Historically controlled studies
Level V	N/A	Mechanism-based Reasoning[a]	Mechanism-based Reasoning	N/A	Mechanism-based reasoning	Mechanism-based reasoning

[a] Such reasoning will involve an inferential chain linking the intervention (expert opinion, based on physiology, animal or laboratory studies).

Table 2. Sections of a manuscript.

Title	The manuscript title implies the maximum role of notoriety and disclosure; it works as first-hand advertising to interested parties and potential readers. It must be specific and clear [8].
Author(s)	All authors who have contributed intellectually to the writing, those responsible for managing, obtaining, or interpreting the data and conclusions, should be considered. Author status is reserved for a contributor who deserves credit and can take responsibility for the work [9].
Key Words	It is an expansion outside the title that helps to delimit or extend the scope and direction of the writing, increasing the possibility of being found by interested parties with similar searches. The descriptive words of the main ideas of the writing should be used.
Abstract	The abstract involves the function and opportunity to describe the content of the writing; usually, in a maximum of 150–200 words, it must accurately represent the content of the writing, representing a quick reference to your article, especially for busy researchers.
Material and Methods	The primary objective of this section is to facilitate and explain in detail clearly the processes and ways in which the problem or research developed; the actions taken by the authors should be narrated in a sequential, logical, and detailed process to replicate the methods used and assess whether the methods justify the conclusions [8].
Manuscript	It is the bulk of the information presented by the author in variable length. It should start with a short introduction, offering relevant context and background, including any previous results that you seek to question or support; As supporting material, graphic summaries, illustrations, figures, and electronic art are valuable tools for providing visual content of the main ideas, concepts, or results presented.
Results	The results are a global and general description of the major results of the study; it should be a clear and concise section, base the sequence of the results with tables, figures, and graphs, clearly emphasize any significant finding. Remember not to interpret the results in this section and reserve it for discussion and conclusion.
Discussion/Conclusions	The discussion selectively recapitulates the content of the writing and presents a perspective of the general message of the article, offering meaning to the results, especially in the context of the existing evidence on the topic. It is important to contrast the exposed results and deductions with the bibliographic material cited, to highlight how the exposed findings and conclusions contribute to the knowledge and understanding of the subject in particular, including an "open invitation" to the scientific community to work on the points not demonstrated in the exposed work [8,11].

[redacted]

The new schemes of data generation in a "Society of knowledge" context are linked to broader terminal objectives than the traditional vision of publishing an original scientific text only. The line of translational knowledge is linked to aspects of innovation and technological development, patenting models, entrepreneurship, and the economy of knowledge.

Because of the enormous offer of scientific exchange worldwide, one of the recent critical subjects is the so-called reproducibility crisis, even in those serious (non-predatory) scientific journals, which are strictly peer-reviewed; in other words, the accuracy of the results shown cannot be reproduced by other groups of researchers when they apply the same methodology described. These origin and systematic failures have eventually led to the retraction of such publications because they are considered fraudulent [11–13].

Finally, it is pertinent to note the relevance of intellectual honesty and the timely application of ethical criteria in scientific communication. Methodological rigor must be compatible with universal criteria and values of respect for the parties' fundamental rights. The veracity of data, avoidance of redundancies and duplication of information, confidentiality, informed consent, declaration of conflicts of interest, funding, and responsibility in co-authorships are some of the daily items that also reflect the integrity of a scientific article [14].

Validation by institutional committees in bioethics and research are now part of the fundamental requirements for the acceptance of viable manuscripts for publication, and these considerations need to be considered.

1. Conclusion

The divulgation of knowledge in neurosurgery is a critical factor for the evolution of science and transcends in the scenario of data generation, as in the educational disciplinary aspects in the formation of human talent. Methodological strengthening is vital to highlight the true innovative sense in scientific reports overall its modalities, according to universal standards, with a critical vision, useful for decision making ethically.

Funding

No funding was received for the development of this report.

Conflicts of interest

The authors declare no conflict of interest.

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Archives of Neurosurgery

Volume 1 | Issue 2 Article 5

2020

Passive Functional Mapping Using Infrared Thermography in Epilepsy Awake Surgery: Case Report

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ARCHIVES OF NEUROSURGERY REVISTA DE DIVULGACIÓN CIENTÍFICA DE LA SOCIEDAD MEXICANA DE CIRUGÍA NEUROLÓGICA A.C., Año 1, No.2 (enero a junio 2022) es una publicación cuatrimestral editada por la Sociedad Mexicana de Cirugía Neurológica A.C., Miami 47, Nápoles, Benito Juárez, 03810 Ciudad de México, CDMX, Tel 52 (55) 5543 0013, https://www.ansjournal.org. Editor: Fiacro Jiménez Ponce. Reserva de Derechos al Uso Exclusivo No. 04-2023-051212055700-102, ISSN: En trámite, ambos otorgados por el Instituto Nacional del Derecho de Autor. Responsable de la última actualización de este número Fiacro Jiménez Ponce, Miami 47, Nápoles, Benito Juárez, 03810 Ciudad de México, CDMX, fecha de última modificación 22 de junio del 2022.

Passive Functional Mapping Using Infrared Thermography in Epilepsy Awake Surgery: Case Report

Abstract

Background: Active Functional Mapping (AFM) is the gold standard method for localizing cortical and subcortical brain functional areas and tracts. By definition, it requires direct application of controlled electrical stimuli under established protocols. Nevertheless, it entails inherent risks, such as causing intraoperative seizures. On the other hand, Passive Functional Mapping (PFM) doesn´t require electrical stimulation of the nervous system. PFM is based on the knowledge that brain metabolism generates different electromagnetic radiation patterns depending on its metabolism, that are invisible to the human eye, but infrared thermographic cameras can show those changes related to brain activity without the use of special light or dyes. **Surgical Technique:** We describe the technique and results with adherence to the care guidelines, of a single case of awake epilepsy surgery with AFM and a new method for performing PFM, developed by the authors. **Case Presentation:** Using an infrared thermographic camera, we detected that the basal cortical temperature increases 2.8 °C while moving the contralateral face, and 2.4 °C while moving the contralateral hand, in their respective primary cortex motor areas as confirmed by AFM. **Discussion:** The infrared thermographic camera allows visualization of the electromagnetic radiation of the brain, without the use of dyes or special lighting in real-time, according to different metabolic conditions related to resting or activation states. **Conclusion:** This new PFM technique should be investigated in a clinical trial, in order to establish its sensibility and specificity.

Visual Abstract

Keywords

Passive Functional Mapping, Active Functional Mapping, Awake Craniotomy, Brain Mapping, Thermography, Brain Metabolism, Case Report

Cover Page Footnote

To Manuel Reyero, for your friendship, commitment and support, and to Brigham Bowles M.D., for correcting the English edition of the manuscript.

Authors

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Passive Functional Mapping Using Infrared Thermography in Epilepsy Awake Surgery: Case Report

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Abstract

Background: **Active Functional Mapping (AFM) is the gold-standard method for localizing cortical and subcortical brain functional areas and tracts. By definition, it requires the direct application of controlled electrical stimuli under established protocols. Nevertheless, it entails inherent risks, such as causing intraoperative seizures. On the other hand, Passive Functional Mapping (PFM) does not require electrical stimulation of the nervous system. PFM focuses on knowing that the brain generates different electromagnetic radiation patterns invisible to the human eye depending on its metabolism. However, infrared thermographic cameras can show those changes related to brain activity without special light or dyes.**

Surgical technique:: **We describe the technique and results with adherence to the care guidelines of a single Case of awake epilepsy surgery with AFM and a new method for performing PFM, developed by the authors.**

Case presentation: **Using an infrared thermographic camera, we detected that the basal cortical temperature increased by 2.8 °C while moving the contralateral face and 2.4 °C while moving the contralateral hand in their respective primary cortex motor areas as confirmed by AFM.**

Discussion: **The infrared thermographic camera allows visualization of the electromagnetic radiation of the brain, without the use of dyes or special lighting in real-time, according to different metabolic conditions related to resting or activation states.**

Conclusion: **This new PFM technique should be investigated in a clinical trial to establish its sensibility and specificity.**

Keywords: Passive functional mapping, Brain mapping, Active functional mapping, Awake craniotomy, Thermography, Epilepsy surgery, Brain metabolism, Case report

1. Introduction

Since the first time the faradic current was delivered directly to the brain in 1874 by Roberts Bartholow [3,9,13,14], it has been clear that a standardized methodology for its use is mandatory to obtain reliable results with lower risks. The history of cortical stimulation and brain location has gone through a long and continuous learning curve. Nevertheless, even with the modern technique, the Active Functional Mapping (AFM) that requires delivering electric currents directly to the brain can cause intraoperative seizures [11], which can add morbidity to the surgery. The AFM has other disadvantages, as it requires a considerable amount of clinical experience using the technique to make it reliable, and it is specific only for few functions. Furthermore, it is hard to obtain reliable results

Received 18 August 2020; revised 28 November 2020; accepted 14 March 2021.
Available online ■ ■ ■

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using AFM in the pediatric population under five years old because of their incomplete myelinization process [8]. AFM remains the gold standard for brain function localization; nevertheless, due to its well-known disadvantages [12], noninvasive methods such as functional magnetic resonance imaging (fMRI) and diffusion tensor imaging have been developed and proven effective. Blood-Oxygen-Level-Dependent (BOLD) fMRI maps the brain by detecting perfusion-related changes coupled with neuronal activity [10]. Positron Emission Tomography can detect hypometabolic brain zones that correlate to irritative zones in epilepsy. Single Positron Emission Computed Tomography (SPECT) can demonstrate low metabolic zones in interictal periods and high metabolic zones during seizures. These diagnostic tools teach us that brain metabolism variations are directly related to brain function activation of brain functions, whereas epilepsy alters its metabolism. By definition, Passive Functional Mapping (PFM) is not invasive, does not deliver electric current to the brain. PFM focuses on knowing that the brain generates different electromagnetic radiation patterns invisible to the human eye depending on its metabolism. However, infrared thermographic cameras can show those changes related to brain activity without special light or dyes and are therefore inherently safer.

The brain has high energy requirements. About 20% of the oxygen and 25% of the glucose consumed by the human body are dedicated to cerebral functions, yet the brain represents only 2% of the total body mass. The main processes contributing to the high brain energy needs are maintaining and restoring ion gradients dissipated by signaling processes such as postsynaptic action potentials, uptake, and recycling of neurotransmitters [1,2]. Thus, there is a tight vascular and metabolic coupling between demand and supply in brain energy consumption by task-dependent increases in cerebral activity, local blood flow, and glucose utilization [3,4]. This so-called functional hyperemia results from the increased neuronal activity and blood flow in which astrocytes play a key role. In addition, increasing evidence has linked astrocytes to neurotransmitter recycling and anaplerosis. Thus, while the brain is a high energy-consuming organ, it contains little energy reserves and depends on the uninterrupted supply of energy substrates from circulation [3]. A new frontier is the real-time intraoperative measurement of brain metabolism fluctuations. Infrared thermographic cameras can make this metabolic electromagnetic radiation visible to the human eye; therefore, we propose that it could be helpful to develop PFM protocols [5–7].

Abbreviations

AFM	Active Functional Mapping
BOLD	Blood-Oxygen-Level-Dependent
°C	Centigrade degrees
ECoG	Electrocorticography
fMRI	Functional Magnetic Resonance Imaging
PFM	Passive Functional Mapping
SPECT	Single Positron Emission Computed Tomography

2. Surgical technique

During a sleep-awake-sleep craniotomy under local anesthesia and sedation, we performed a cortical language and motor AFM, electrocorticography (ECoG), and PFM. The operating room temperature remained constant at 20 °C with a relative humidity of 40%. The patient's esophageal temperature was 33.6 °C, and his vital signs remained within physiological range trans surgically. We recorded his dura mater temperature using a laser infrared pointer thermometer (Floureon©). We reversed sedation, and the neuropsychologist confirmed that the patient was fully awake and in his basal state. Guided by the neuro-navigation system plan (Fig. 1-A) immediately after the dura incision, we performed a basal PFM using an acetate sterile perforated grid with coordinates of the exposed cortex. We first used the laser infrared pointer thermometer; after removing the acetate grid, we used a thermal imaging camera (Kmoon©) which combines the pictures taken with surface temperature measurements to provide real-time thermal imaging. We recorded brain temperature while the patient was awake, resting, speaking, moving the right face, hand, and arm through a perforated acetate grid as close as possible to the brain to obtain optimal accuracy as previously published (Fig. 1-B) [5–7] We set the emissivity of the camera to 95 in all thermographic readings. We recorded all data for further analysis.

Immediately after, we performed the AFM using an Ojemann cortical stimulator (Integra NeuroSciences©, England) to locate speech, face, and motor cortex areas. We successfully located the primary motor cortex for the contralateral hand and face. No speech arrest was produced during cortical electrical stimulation. Next, the ECoG guided a tailored corticectomy of the left frontal pole, pars triangularis, and pars opercularis. We repeated none of the mapping modalities because the patient was getting

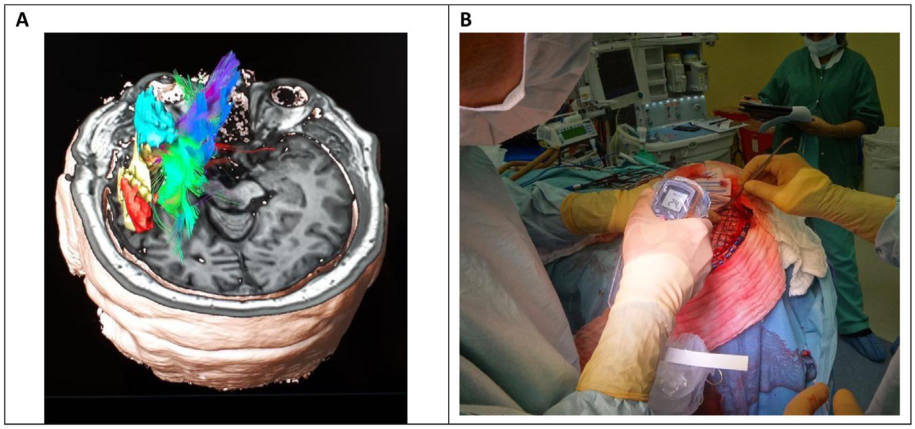

*Fig. 1. **A:** Neuro-navigation planning. The region of interest is shown in cyan. Relevant tracts are shown in blue, green, yellow, and red. **B:** Thermographic thermometer, perforated acetate grid, and camera position during PFM. To avoid emissivity registration errors, the thermographic devices should be placed as close and perpendicular to the exposed cerebral cortex.*

anxious and exhausted. Before closing the dura mater, the patient was fully anesthetized, and the surgical procedure was uneventful. The patient was discharged from our hospital four days later, with no surgery-related morbidity. He is seizure-free since the epilepsy surgery at Engel grade I.

3. Case presentation

The objective of the Case presentation is to describe the technique and results of a single case of awake epilepsy surgery with active brain functional mapping and a new method for performing passive functional mapping developed by the authors. The case presentation is in accordance to care guidelines.

In our case presentation, we had a right-handed 55 years old male with normal neuropsychological development. His previous non-neurological medical personal and family history was unremarkable, except for a lumbar disc herniation and hypertension with adequate control. At the age of 13, he underwent a craniectomy for a traumatic brain injury in another hospital. Unfortunately, he remained with the cranial defect for four years. His cognitive sequelae included slurred speech, abstract processing, and writing production deficiencies, suggesting damage to the parietal, angular, and motor cortex circuits.

Nevertheless, he described a slow and subtotal improvement in these functions. At 17 years of age, he

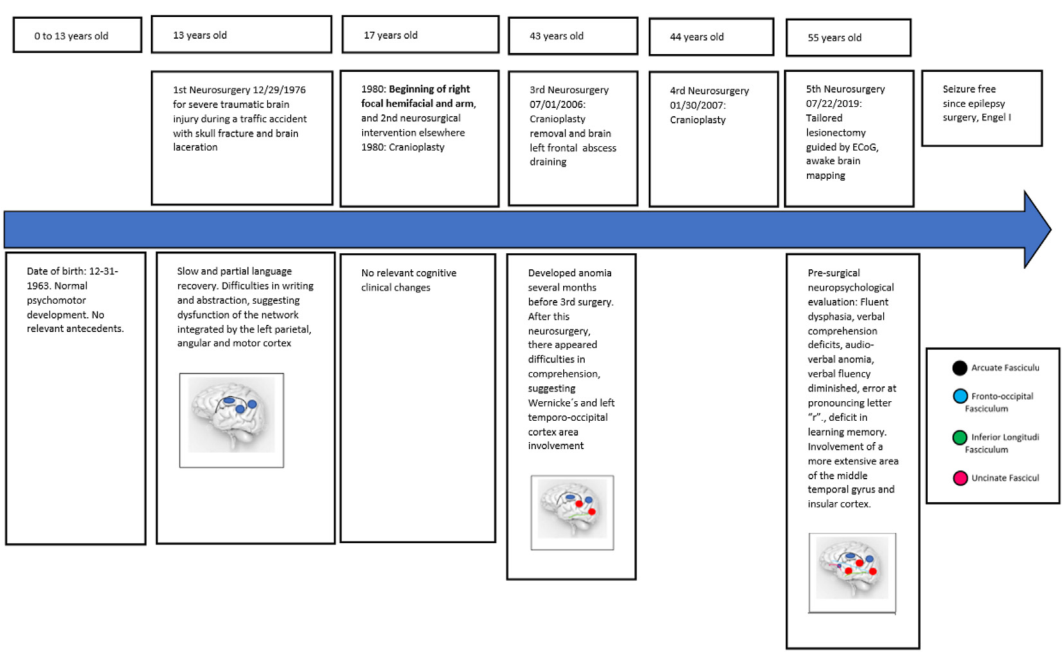

Fig. 2. The timetable of relevant events and data of our Case presentation history.

began to experience focal motor seizures of the right hemiface, hand, and arm in clusters every six months on average. Cranioplasty was performed uneventfully. He was then started on valproate, topiramate, and levetiracetam under medical surveillance by several neurologists. He had adequate seizure control then after, including a long interictal period of 10 years. In his early 30's, the frequency and intensity of his seizures gradually increased to up to 1 every 48 h on average, with disabling postictal periods of fatigue. At 33 years old, he developed a soft tissue infection, and the cranioplasty material was removed, and an unknown antibiotics scheme was completed. A successful second cranioplasty was performed a year later in another hospital (Fig. 2).

At 41 years old, he began to develop paraphasia. His seizure frequency gradually increased at clusters of 3—4 seizures on average every two days, with each seizure typically lasting about 3 min with postictal somnolence for the next 24 h. Due to poor seizure control, several antiepileptic were given either in mono or polytherapy schemes. However, he remained uncontrolled for three years before being referred to our center as a candidate for epilepsy surgery. His physical exam was unremarkable, except for the cognitive sequelae and the left craniectomy defect (Fig. 2). The interictal electroencephalogram was consistent with focal irritative activity in the frontal-basal region. In addition, we performed an fMRI showing activation of language in the right opercular region (Fig. 3). After a multidisciplinary staff meeting of our Epilepsy Committee, the patient was selected for surgery. Our hospital's ethics and research committee authorized the AFM and the PFM protocols, and the patient signed an informed consent form.

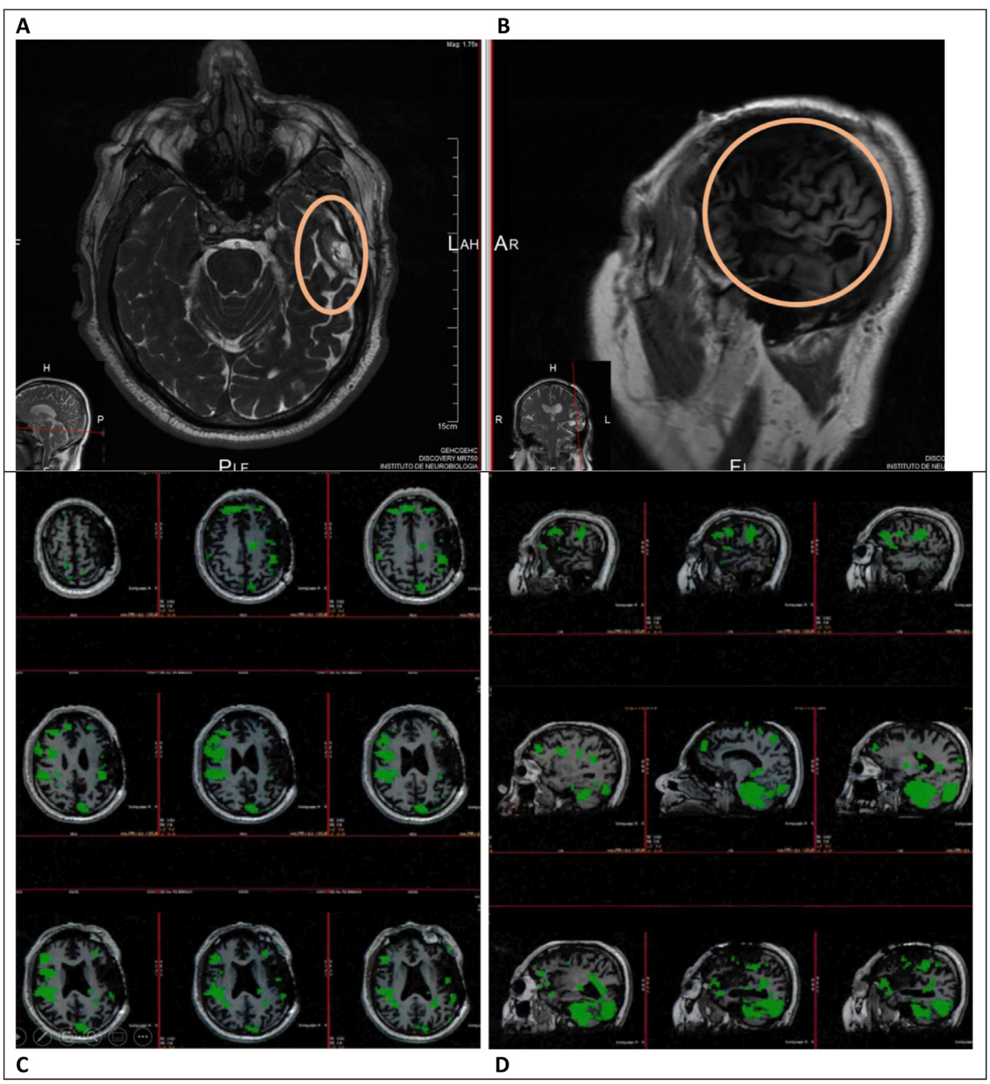

Fig. 3. A and B: sagittal T1 and coronal T2 MRI. Note the yellow ovals that show the encephalomalacia zone in the left temporal lobe and pars opercularis, pars triangularis, and in the second frontal gyrus; C and D: fMRI shows metabolism activation while speaking in the right hemisphere.

3.1. Infrared thermography passive mapping results

The basal infrared thermography picture was taken with the patient fully awake and resting. Then, different infrared thermographic pictures were taken while the patient spoke and moved the right face and hand. The maximal brain temperature at resting state was 32.1 °C; while moving the contralateral face, it rose to 34.9 °C (difference in brain temperature (Δt) = 2.8 °C), and while moving the right hand it rose to 34.5 °C (Δt = 2.4 °C) in their respective primary cortex motor areas, as confirmed later by AFM (Fig. 4).

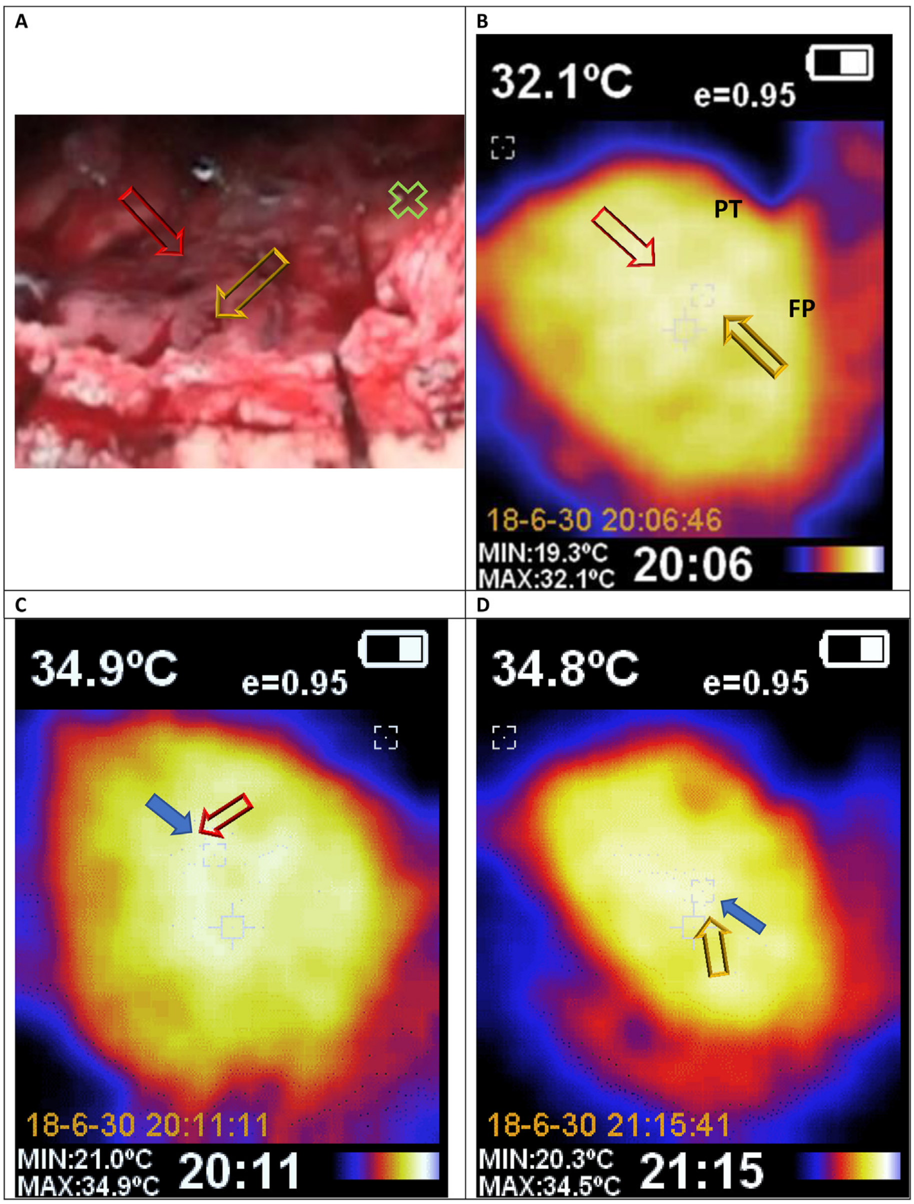

*Fig. 4. **A:** Panoramic picture showing the brain surface of the left frontal lobe exposed. PT: pars triangularis, FP: Frontal Pole; the grey box with lines ( ) identifies the center of the picture; the gray box without lines ( ) identifies the maximal temperature point (the infrared camera automatically generates both); red arrow shows the face primary motor area and the yellow arrow shows the hand primary motor area according to the AFM; the green X shows the frontal pole. **B:** Basal infrared thermography recording picture with the patient awake and resting. **C:** Infrared thermography picture moving the contralateral face. **D:** Infrared thermography picture moving the right hand. The blue arrows show the maximal brain temperature recording in C and D. The maximal cortex temperature while the patient is awake and resting = 32.1 °C; moving contralateral face = 34.9 °C; moving the right hand 34.5 °C. Note the rise in brain temperature of 2.8 °C while moving the contralateral face and of 2.4 °C while moving the contralateral hand.*

3.2. Active mapping results

There was no negative response (speech arrest) during the electrical stimulation of the left frontal basal and opercular region. Active movement of the contralateral face and hand were elicited during electrical stimulation of the primary motor area. During the final phase of the AFM, the patient suffered a focal motor seizure affecting the right face, arm, and hand, which we controlled after 40 s of cerebral cortex irrigation with cold, sterile isotonic saline solution.

3.3. Comparison of active and passive mapping results

The hand and facial primary motor cortex regions identified with the AFM correspond with the regions where temperatures rose during PFM during movement of the corresponding body areas. No motor cortex areas related to speech were identified during the AFM or the PFM. The infrared thermography PFM observed a regional temperature rise in the facial and hand primary motor cortex during the movement of these body parts (Fig. 3).

3.4. Electrocorticography results

We used ECoG to detect a constantly active irritative zone placing a 20 electrodes grid over the left pars triangularis, pars opercularis and frontal pole with encephalomalacia. This irritative zone was removed during tailired corticectomy.

4. Discussion

The brain is an adiabatic and isentropic thermodynamic system. As thermodynamics defines the information systems, and the brain meets those criteria, they can only exchange electromagnetic irradiation data. The thermomagnetic irradiation is emitted in the infrared spectrum, invisible to the human eye. Infrared thermographic cameras can detect and measure this irradiation in real-time. While AFM remains the gold standard to detect functional brain zones and tracts, in this Case presentation, we demonstrated the use of multiple brain mapping methods to help identify crucial motor cortex areas, helping deliver more efficient and safer treatments. A weakness of this technical note is that we could not repeat the infrared thermography PFM to confirm the result because the patient was getting anxious and tired during the cortical mapping. In addition, as we used a thermographic camera that cannot record video, we could not document how long the raising in the primary motor cortex temperature lasts. We will use a thermographic video camera for future cases.

The infrared thermographic camera allows the observer the visualization of the electromagnetic irradiation of the brain in real-time without the use of dyes or special lighting according to different metabolic conditions related to resting or activation states. The applications of infrared thermography in general surgery and neurosurgery could be very diverse. To mention some examples, it would help identify epilepsy foci, cortical or subcortical tumors, vascular lesions [5], brain abscess, parasitic infections to surveillance in aneurism clipping [6]. Its disadvantages for PFMis the lack of standardization, requirement of a high definition thermographic camera, sensibility and specificity yet to be established, and the learning curve. The advantages are that it does not need direct electrical stimuli over the brain cortex, its safeness, non-invasiveness, and cheapness, no need for dyes, contrasts, or special light, and it shows encephalic electromagnetic metabolic changes in real-time.

5. Conclusion

This new technique of PFM should be investigated in a case series to establish its sensibility and specificity in various other clinical conditions.

Funding

This research has not had any financial support.

Conflicts of interest

There are no conflicts of interest to report.

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ARCHIVES OF NEUROSURGERY

Archives of Neurosurgery

Volume 1 | Issue 2 Article 6

2020

The Many Worlds of Neurosurgery and the Labyrinth of Borges

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ARCHIVES OF NEUROSURGERY REVISTA DE DIVULGACIÓN CIENTÍFICA DE LA SOCIEDAD MEXICANA DE CIRUGÍA NEUROLÓGICA A.C., Año 1, No.2 (enero a junio 2022) es una publicación cuatrimestral editada por la Sociedad Mexicana de Cirugía Neurológica A.C., Miami 47, Nápoles, Benito Juárez, 03810 Ciudad de México, CDMX, Tel 52 (55) 5543 0013, https://www.ansjournal.org. Editor: Fiacro Jiménez Ponce. Reserva de Derechos al Uso Exclusivo No. 04-2023-051212055700-102, ISSN: En trámite, ambos otorgados por el Instituto Nacional del Derecho de Autor. Responsable de la última actualización de este número Fiacro Jiménez Ponce, Miami 47, Nápoles, Benito Juárez, 03810 Ciudad de México, CDMX, fecha de última modificación 22 de junio del 2022.

The Many Worlds of Neurosurgery and the Labyrinth of Borges

Abstract

Nowadays, an apprentice of neurosurgery has to complete long and different pathways of education.The encounter between the schools of Napoli and Tucuman, make us identify a common strategy of neurosurgical education. In attempt of defining the philosophy behind it we attempt a comparison in between the life and training of a modern neurosurgeon and the character of a tale of Borges (i.e. Ts'ui Pên). As neurosurgeons of the 21st century we must be like the inextricable Ts'ui Pên.

Visual Abstract

Keywords

Neurosurgical training, surgical education, teamwork

Cover Page Footnote

NOTES Conflict of interest: The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript. Funding source: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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The Many Worlds of Neurosurgery and the Labyrinth of Borges

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Abstract

Nowadays, an apprentice of neurosurgery has to complete long and different pathways of education.

The encounter between the schools of Napoli and Tucuman, make us identify a common strategy of neurosurgical education.

In attempt of defining the philosophy behind it we attempt a comparison in between the life and training of a modern neurosurgeon and the character of a tale of Borges (i.e. Ts'ui Pên).

As neurosurgeons of the 21st century we must be like the inextricable Ts'ui Pên.

Keywords: Neurosurgical training, Surgical education, Teamwork

Over the last decades, the discipline of neurosurgery has evolved at a vertiginous pace. Therefore, young neurosurgeons face a real dilemma in their first steps in life: they need to create a solid backbone of theory, to lean the training toward their favorite field of knowledge, and, above all, to enter their network guild to share ideas. Hence, they must continue medical education, practice surgical skills, produce research, attend congresses and symposia, embrace technological advances, learn foreign languages, acquire political skills, and keep human-sensitive while providing healthcare, among the others.

Should a single person demonstrate all these skills? Or, should the neurosurgeon of the twenty-first century focus on a single interest?

We will try to identify this common thread, which could be considered the main path of education in neurosurgery, paralleling the thinking of the renowned writer Jorge Luis Borges.

1. The surrealistic paths of Borges

The Argentinian literate Jorge Luis Borges published a tale in 1941 entitled "The Garden of the Forking Paths." It is a police piece where Yu Tsun, a spy, and the protagonist, is chased by Captain Richard Madden. Yu Tsun aims to kill a wise sinologist, Stephen Albert. The victim recognizes Yu Tsun as the great-grandson of Ts'ui Pên, a Chinese astrologer famous for having defined two impossible tasks: building an infinitely complex maze and writing an endless book. Albert reveals to Yu Tsun that he has discovered the enigmatic secret behind the ideas of his ancestor; the book is a labyrinth, non-spatial but temporary [1].

In a paragraph of the tale, we can read:

> *"In all fictional works, each time a man is confronted with several alternatives, he chooses one and eliminates the others; in the fiction of Ts'ui Pên, he chooses,* ***simultaneously, all of them****. He creates, in this way, diverse futures, several times, which themselves also proliferate and* ***fork****. Here, then, is the explanation of the novel's contradictions"* [2].

This paradox has gained further relevance thanks to the famous works in Physics of Hugh Everett III. He published his Ph.D. thesis "The Relative State Formulation of Quantum Mechanics" in 1957.

In section five of the original study, Everett says:

Received 30 June 2020; revised 19 January 2021; accepted 6 August 2021.
Available online 28 January 2022

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ISSN-Pending. Published by Mexican Society of Neurological Surgery (Sociedad Mexicana de Cirugía Neurológica A.C.).

BORGES

*"The trajectory" of the memory configurations of an observer performed sequence is thus not a linear sequence of memory configurations, but **a branching tree**, with **all the possible outcomes existing simultaneously** in a final superposition with different coefficients in the mathematical model"* [3].

Both the American physicist and the Argentinian writer present the idea strikingly similar: the garden is the image of the universe as Ts'ui Pên conceived it, and if we accept Everett's hypothesis, the world is a garden of forking paths [1].

2. The crossing routes of current neurosurgery

Nowadays, neurosurgery embraces a conspicuous number of subspecialties, and, accordingly, an apprentice of this art has to complete long and different pathways of education.

2.1. Surgical techniques

Along with the development of the various surgical procedures, the innovations and advancements in visualization, lighting, and magnification of the surgical field can be definitely advocated as keystones. We can date the first true revolution in 1957 when Kurze moved his efforts to introduce the microscope in neurosurgery [4]; at that time, Yasargil began his legacy to be later recognized by a whole generation of neurosurgeons as a real quantum leap for understanding and practice. In the following years, the need to unveil the hidden corners and shady areas without completing extensive opening and bone removal, especially at the skull base, afforded the introduction and widespread of the endoscope in neurosurgical procedures. It was helpful in the navigation of ventricles, in removing sellar tumors and accessing the median and paramedian skull base [5,6,7]. More recently, the exoscope - offering a concrete synthesis of the features of the two tools - has been developed and brought into the neurosurgical community [8]. We should admit that these three visualizing resources have independently pushed the development of so many different surgical techniques in quite a short time. Each one of them requires specific training and a good learning curve to achieve adequate confidence. In this environment, the young neurosurgeon acquires advanced skills and may opt for one of the ways, but they should be trained in as many techniques as possible.

2.2. Surgical praxis

Various training programs have been developed according to the level of surgical practice, which residents need to acquire [9] particularly we underline the relevance of refining praxis. It is crucial to have adequate case-load in the training center [10], practice various exercises outside the time of surgery, and attend the hands-on courses [11]. Today, the selective and dedicated environment of the different fields of neurosurgery allowed the young practitioners to acquire praxis through intensive training focused on the peculiar skills of the specific procedures.

Abbreviations	
e.g.	exempli gratia

2.3. Anatomical knowledge

The key to achieving an adequate understanding of a surgical technique is the knowledge of anatomy [12,13]; we firmly believe that cadaveric dissection rehearsal is mandatory.

2.4. Research and technological advances

Scientific research is the cornerstone to build knowledge and advancement in practice [14,15]; it also allows sharing achievements in the community and congresses and symposia. For these reasons, the young neurosurgeon must be at the forefront of technological advances, but at the same time, it should be acquired judiciously.

2.5. Politics and humanitarian medicine

Socially, neurosurgeons are expected to handle controversies, support teammates, and evenly provide the best possible neurosurgery. This requires a high dose of generosity and desire to fight against injustice: it also invokes a mixture of romanticism, utopia, and spirit of adventure, along with political skills [16,17].

3. The many worlds of the neurosurgeon's life in the twenty-first century

The encounter between Napoli and Tucuman's schools makes us identify a common strategy of education many young staff neurosurgeons have run to complete their training. To define the philosophy behind it, we attempt to compare the social life and professional training of a modern neurosurgeon and the character of the tale of Borges.

The twentieth century's surgeon, whenever challenged with the different activities, opts for one (e.g., operating room) and eliminates the others (e.g., research); the multifaceted surgeons of the twenty-first century, **should opt "simultaneously" for all**: in this way, they move along several routes, adopt new ideas, which also proliferate and **bifurcate** and indeed progresses. Therefore, as young avant-garde neurosurgeons, we should strive to acquire knowledge of the multiple worlds to ensure the most adequate and complete neurosurgical care [18].

As neurosurgeons of the twenty-first century, paraphrasing Borges, we must be **like the inextricable Ts'ui Pên**.

Funding source

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Financial disclosure

No.

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Archives of Neurosurgery

Volume 1 | Issue 2 Article 7

2020

An unusual case of a giant intradiploic epidermoid cyst removed using a combined supra-infratentorial retromastoid approach.

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ARCHIVES OF NEUROSURGERY REVISTA DE DIVULGACIÓN CIENTÍFICA DE LA SOCIEDAD MEXICANA DE CIRUGÍA NEUROLÓGICA A.C., Año 1, No.2 (enero a junio 2022) es una publicación cuatrimestral editada por la Sociedad Mexicana de Cirugía Neurológica A.C., Miami 47, Nápoles, Benito Juárez, 03810 Ciudad de México, CDMX, Tel 52 (55) 5543 0013, https://www.ansjournal.org. Editor: Fiacro Jiménez Ponce. Reserva de Derechos al Uso Exclusivo No. 04-2023-051212055700-102, ISSN: En trámite, ambos otorgados por el Instituto Nacional del Derecho de Autor. Responsable de la última actualización de este número Fiacro Jiménez Ponce, Miami 47, Nápoles, Benito Juárez, 03810 Ciudad de México, CDMX, fecha de última modificación 22 de junio del 2022.

An unusual case of a giant intradiploic epidermoid cyst removed using a combined supra-infratentorial retromastoid approach.

Abstract

Background*:* Epidermoid cysts (EC) are relatively rare congenital lesions. They arise from ectodermal debris during aberrant closure of the neural tube, are benign, and of slow growth. They are found predominantly in the cistern of the cerebellopontine angle, most are intradural, and very rarely, there is underlying compression of the venous sinuses, leading to benign intracranial hypertension.

Case description:We present the case of a patient diagnosed with a giant extradural, intradiploic EC with compression of the left transverse sinus and its successful management by using ultrasonic aspiration, performing a combined supra-infratentorial retromastoid approach with occipitotemporal craniotomy, without subsequent residual tumor.

Conclusion: We report the diagnostic approach of the EC and its successful management without the added neurological deficit and considerable improvement in previous symptoms. The retromastoid approach is a safe and effective approach for managing these tumors, including complete resection of the cystic and capsular components. However, it requires adequate surgical management with prior planning, a multidisciplinary therapeutic approach, and long-term follow-up, given the possibility of recurrence.

Visual Abstract

Keywords

Epidermoid cyst, transverse sinus, cerebellopontine angle, retromastoid approach.

Cover Page Footnote

To all medical personnel involved in the integral management of the patient.

Authors

César Adán Almendárez-Sánchez, Saúl Solorio-Pineda, Abrahan Alfonso Tafur-Grandett, Miguel Ángel Ramírez-Sosa Dr., Gabriel Arturo Ramos Martínez, and Leonardo Álvarez-Vázquez

An Unusual Case of a Giant Intradiploic Epidermoid Cyst Removed Using a Combined Supra-Infratentorial Retromastoid Approach

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Abstract

Background: **Epidermoid cysts (EC) are relatively rare congenital lesions. They arise from ectodermal debris during aberrant closure of the neural tube, are benign, and of slow growth. They are found predominantly in the cistern of the cerebellopontine angle, most are intradural, and very rarely, there is underlying compression of the venous sinuses, leading to benign intracranial hypertension.**

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Conclusion: **We report the diagnostic approach of the EC and its successful management without the added neurological deficit and considerable improvement in previous symptoms. The retromastoid approach is a safe and effective approach for managing these tumors, including complete resection of the cystic and capsular components. However, it requires adequate surgical management with prior planning, a multidisciplinary therapeutic approach, and long-term follow-up, given the possibility of recurrence.**

Keywords: Epidermoid cyst, Transverse sinus, Cerebellopontine angle, Retromastoid approach

1. Background

The epidermoid cyst (EC) was first described in 1829 by Par J. Cruveilhier as “a tumor with a metallic shine like silver or like a pearl of the finest water”; therefore, it is also synonymous with a pearl tumor [1].

EC represents 0.2–1.8% of all primary intracranial tumors and 4–7% of cerebellopontine angle lesions (CPA) [2]. They are predominantly intradural (up to 90%), extradural cysts are less frequent, within 10–25% [3]. It is also unusual for the tumor to cause compression of the venous sinuses.

CT and MRI are fundamental diagnostic tools to gain helpful information for surgical programming. Non-enhanced CT scans show a well-defined, lobulated, low-density mass insinuating around the cisterns. MRI allows to characterize the lesion better, showing a low-intensity signal on T1-weighted images, high-intensity on T2-weighted images, FLAIR heterogeneous signal (due to cholesterol and cellular debris) with moderate peripheric enhancement, and diffuse hyper signal [4].

Sometimes, the cyst contents can be hyperdense, mimicking a hemorrhage. Complete surgical excision is associated with permanent cure, minimal

Received 17 October 2020; revised 16 June 2021; accepted 15 August 2021.
Available online ▪ ▪ ▪

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ISSN Pending. Published by Mexican Society of Neurological Surgery (Sociedad Mexicana de Cirugía Neurológica A.C.).

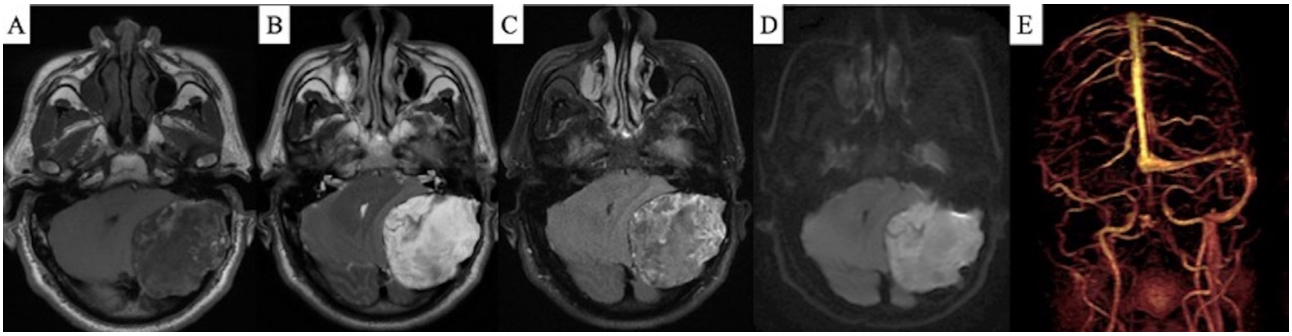

Fig. 1. Brain MRI scan in its different sequences at the posterior fossa level. Presence of left temporal extra-axial tumor and extension to the posterior fossa.

operative mortality, and good long-term prognosis [5].

2. Case description

2.1. Patient

We present the case of a 56-year-old male with a 6-year history of occipital headache, managed with analgesics. Three months prior to his admission, he presented an alteration for walking and vertigo. On admission, a physical exam revealed unaltered consciousness with left peripheral facial paralysis, right hemiparesis, and left hemispheric cerebellar syndrome.

2.2. Imaging

We performed a brain MRI, the contrast-enhanced T1 sequence (Fig. 1A) demonstrated a posterior petrosal intradiploic extra-axial hypointense lesion, presenting a thin capsule with minimal enhancement. In T2 weighting (Fig. 1B), we observed the hyperintense and heterogeneous lesion with an internal displacement of the dura, as well as collapse and displacement of the fourth ventricle. In the FLAIR sequence (Fig. 1C), we observed well-defined hyperintense lesions without appreciating perilesional edema. In DWI (Fig. 1D), we appreciate high signal lesions with partially restricted diffusion. In the MRI with reconstruction (Fig. 1E), we observed amputation of the left transverse sinus, given the absence of permeability due to obstruction by the lesion.

2.3. Surgery

We decided to perform surgical management using a combined supra-infratentorial retromastoid approach. We marked a curvilinear incision in the retromastoid region with a supratentorial extension (Fig. 2A). Soft-tissue dissection is performed up to the skull, showing bone resorption (Fig. 2B). Next, we performed an occipitotemporal craniotomy observing a pearly intradiploic lesion in the temporal bone. The lesion grew to the epidural space and extended to the posterior fossa (Fig. 2C). We used an ultrasonic aspirator for microsurgical removal (Fig. 2D). The tumor was removed entirely, including the cystic content and capsule, observing a clean surgical site (Fig. 2E). The tissues are closed by planes in a conventional way (Fig. 3F). The macroscopic aspect of the lesion was suggestive of EC. The lesion was avascular, the capsule was translucent, and the cyst contained white flakes. The histopathological exam revealed stratified squamous tissue lining with abundant keratin congruent with an EC.

2.4. Postoperative evaluation

There were no postoperative adverse events. After a 5-day hospital stay, the patient presented considerable improvement in the neurological condition with the recovery of muscular strength and without symptoms of the cerebellar syndrome, with postoperative cranial CT scan (Fig. 3) and MRI (Fig. 4) without evidence of residual tumor.

3. Discussion

Malformative tumors derive from the embryonic-fetal cells within the craniospinal cavities. They are most common in the supratentorial space. The most frequent subtypes are craniopharyngioma, glioneuronal hamartomas, MEAN (meningo-encephalo-angioneurinomatosis, the MEAN disease), Rathkes cyst, colloid cyst, lipoma, and the EC [6].

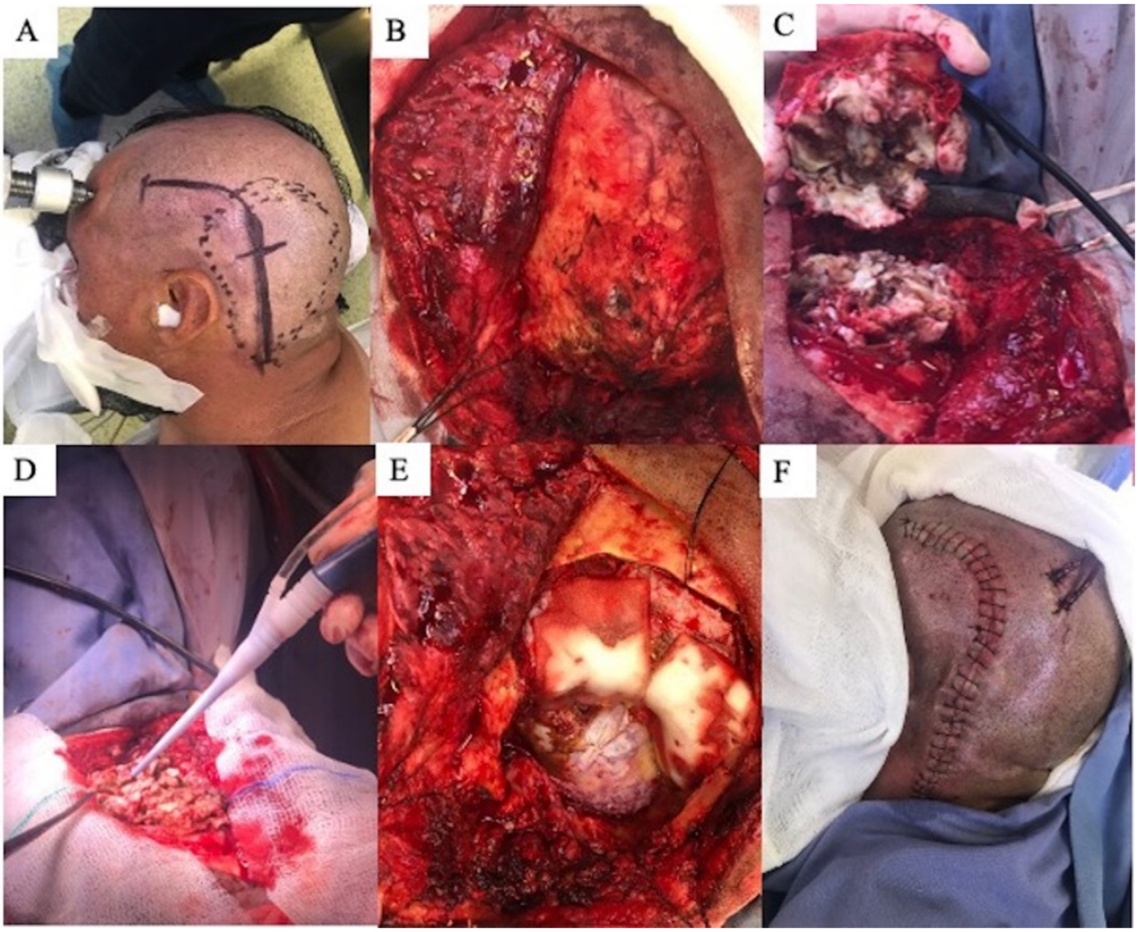

Fig. 2. Intraoperative photographs of surgical management. A combined supra and infratentorial retromastoid approach were performed, identifying an intradiploic tumor.

Fig. 3. Posoperative head CT scan. We showed no residual tumor.

ECs are benign and slow-growing lesions that account for about 0.2%–2% of all intracranial tumors. Intracranial ECs are most often intradural, but they can also occur extradurally in the intradiploic space in up to 10% of cases. In addition, they tend to insinuate into several intracranial compartments by filling the subarachnoid space [7].

The EC arises from ectodermal remains during an aberrant closure of the neural tube in neuroembryogenesis between the third and fifth week of

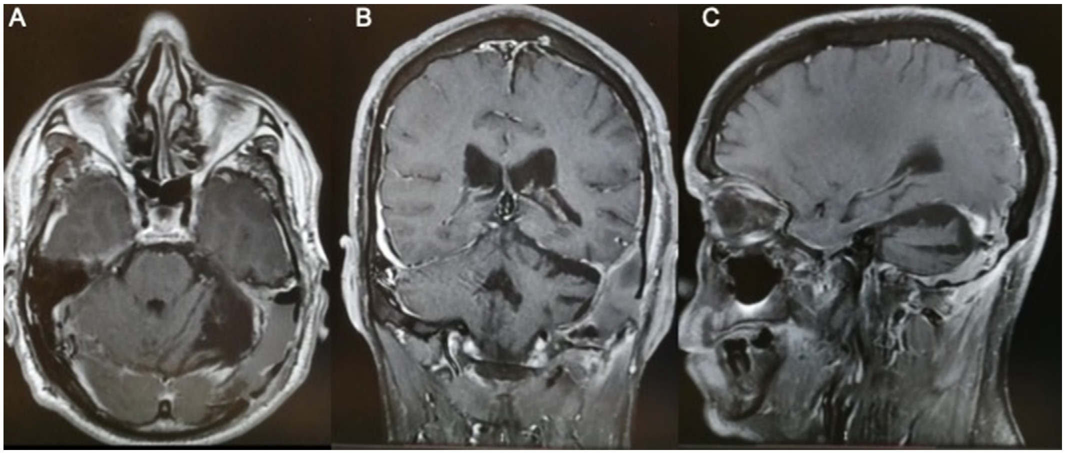

Fig. 4. Postoperative MRI after surgery with axial (A), coronal (B), and sagittal (C) perspectives. We found no detectable residual tumor.

gestation when sequestration of epiblasts occurs in the neural tube [8].

The age of presentation is 40 years, representing 4–7% of lesions of the cerebellopontine angle (CPA), considered the third most common tumor in this region after acoustic schwannoma and meningiomas [8]. They also occur in the fourth ventricle (17%) and the sellar or para-sellar regions (10%–15%). Less common locations include the cerebral hemispheres or the brainstem [3]. In addition, 10% of these lesions are extradural and rarely cause occlusion of the venous sinuses [9]. They are characteristically outside the midline [3].

Histologically they are composed of a stratified squamous epithelium with abundant keratin. Desquamated epithelial cells are rich in cholesterol and, although EC's are usually solid, they may have a liquid cystic center [10].

Given the slow tumor growth, they have an insidious and prolonged course of symptoms and signs. They may have hearing loss, tinnitus, vestibular symptoms, headache, hemifacial spasm, and trigeminal neuralgia. They propagate along the pathways of least resistance (i.e., regular excision planes and anatomical channels), extend to more than one cranial fossa, and surround vital neurovascular structures. However, malignant degeneration of epidermoids in cell carcinoma scaly is rare (21 cases reported between 1965 and 2018) [11].

Most of the EC's are hypointense on T1 and hyperintense on T2 concerning the brain parenchyma. These tumors do not show suppression in FLAIR, and they have diffusion restriction (DWI). They usually present capsular enhancement and the absence of perilesional edema. They can present calcifications in 10%–25% of cases [3].

Extradural epidermoid cysts are intradiploic in approximately 25% of the cases and predominantly supratentorial in location. Infratentorial intradiploic epidermoids are not rare, whereas the giant variants are extremely rare [12,13].

The most common differential diagnosis is arachnoid cysts. Other less common considerations include craniopharyngiomas, Rathke's cleft cysts, and tumors that form cystic components, including pilocytic astrocytomas, hemangioblastomas, and gangliogliomas. Other mimics of EC's include dermoid cyst and neurocysticercosis [10].

The location generally determines the surgical approach and the extent of the lesion, when it occurs in the CPA, is approached by a retromastoid (retrosigmoid) craniectomy. In contrast, a supratentorial extension needs a combined retromastoid and subtemporal approach or a staged procedure [14].

These cysts are benign lesions that could suggest conservative treatment with planned follow-up. On the other hand, more aggressive management with surgical excision is advocated since they tend to grow and erode the skull. In addition, they can become complicated due to rupture or infection of the lesion. Aseptic chemical meningitis secondary to rupture of the epidermoid lining has also been reported [15].

The growth of these lesions is linear, not exponential so that symptomatic recurrence can occur years after surgical resection; Even after subtotal resection, an approximate interval of 8 years has been reported for second surgery with an estimated recurrence of 8.2–25% of cases [16].

Diploic veins contribute to the absorption of cerebrospinal fluid through the arachnoid villi. This system decreases intracranial pressure as a route of bypassing the cerebrospinal fluid under certain pathological conditions. In such a way, it can help to avoid critical intracranial hypertension during the slow growth of an epidermoid cyst with compression of a venous sinus [17].

4. Conclusion

Intradiploic extradural EC with compression of venous sinuses, as in the case of our patient, is a rare presentation. We report the diagnostic approach and its successful management using a combined supra- and infratentorial retromastoid approach without the added neurological deficit and considerable improvement in previous symptoms. The retromastoid approach is a safe and effective approach for managing these tumors, including complete resection of the cystic and capsular components. Despite not being the first possibility in frequency concerning CPA tumors, we must always consider EC given the risk of capsule rupture or lesion extension with skull erosion. It requires adequate surgical management with prior planning, a multidisciplinary therapeutic approach, and long-term follow-up, given the possibility of recurrence.

Conflicts of interest

The authors declare no conflict of interest.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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ARCHIVES OF NEUROSURGERY

Archives of Neurosurgery

Volume 1 | Issue 2 Article 8

2020

L5-S1 Collapsed Space Is Not A Contraindication For ELIF. Technical Note And Preliminary Clinical Results

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ARCHIVES OF NEUROSURGERY REVISTA DE DIVULGACIÓN CIENTÍFICA DE LA SOCIEDAD MEXICANA DE CIRUGÍA NEUROLÓGICA A.C., Año 1, No.2 (enero a junio 2022) es una publicación cuatrimestral editada por la Sociedad Mexicana de Cirugía Neurológica A.C., Miami 47, Nápoles, Benito Juárez, 03810 Ciudad de México, CDMX, Tel 52 (55) 5543 0013, https://www.ansjournal.org. Editor: Fiacro Jiménez Ponce. Reserva de Derechos al Uso Exclusivo No. 04-2023-051212055700-102, ISSN: En trámite, ambos otorgados por el Instituto Nacional del Derecho de Autor. Responsable de la última actualización de este número Fiacro Jiménez Ponce, Miami 47, Nápoles, Benito Juárez, 03810 Ciudad de México, CDMX, fecha de última modificación 22 de junio del 2022.

L5-S1 Collapsed Space Is Not A Contraindication For ELIF. Technical Note And Preliminary Clinical Results

Abstract

INTRODUCTION: Extraforaminal lumbar interbody fusion (ELIF) avoids vascular, neural, and genitourinary risks of anterior and lateral techniques. However, many authors consider ELIF to be contraindicated in L5-S1, especially in the case of a collapsed space. Therefore, we aim to provide a technical note for ELIF in the context of an L5-S1 collapsed space and present our experience and the postoperative clinical results of our patients. MATERIALS AND METHODS: We collected data from the records of patients with ELIF L5-S1 level collapsed between March 2020 to June 2021, using for this study sex, age, clinical symptoms, diagnosis, L5-S1 height space, EVA, and ODI pre and post-surgery. This observational report follows the STROBE reporting guidelines. RESULTS: We collected information from 29 patient files with ELIF L5-S1 collapsed level; 55% were women, with an average age of 53.9 years. The mean height L5-S1 pre-surgery was 5.23mm, mean height post-op L5-S1 was 11.38 mm. The mean preoperative Oswestry disability scale score was 42.28, and the mean 1-month postoperative was 15.65. Mean VAS pre-surgery was 8.51 mm, mean VAS post-op 2.41. None of our patients presented neurological, genitourinary, or vascular complications.

DISCUSSION: The data found in this work show that the ELIF technique can statistically modify the height of the L5-S1 interbody space. Additionally, the Oswestry disability index and pain in VAS can be statistically improved. Our data support that ELIF is suitable for collapsed L5-S1 spaces with low complication rates than other approaches. CONCLUSION: Extraforaminal lumbar interbody fusion is a feasible and safe alternative for restoring the L5-S1 disc height with clinical improvement and significant pain control by the use of intradiscal working tubes and bullet-shaped cages,

Visual Abstract

Keywords

ELIF, restore disc height, Collapsed L5-S1 intervertebral disc space

Cover Page Footnote

Acknowledgments to our families and surgical team

Authors

Iris Tatiana Montes González, Sergio Soriano Solis, Manuel Eduardo Soto García, Manuel Rodríguez García, Gerson Reyes Rodríguez., Víctor David López García, and José Antonio Soriano Sánchez

L5-S1 Collapsed Space is Not a Contraindication for ELIF. Technical Note and Preliminary Clinical Results

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Abstract

Introduction: **Extraforaminal lumbar interbody fusion (ELIF) avoids vascular, neural, and genitourinary risks of anterior and lateral techniques. However, many authors consider ELIF to be contraindicated in L5-S1, especially in the case of a collapsed space. Therefore, we aim to provide a technical note for ELIF in the context of an L5-S1 collapsed space and present our experience and the postoperative clinical results of our patients.**

Materials and methods: **We collected data from the records of patients with ELIF L5-S1 level collapsed between March 2020 to June 2021, using for this study sex, age, clinical symptoms, diagnosis, L5-S1 height space, EVA, and ODI pre and post-surgery. This observational report follows the STROBE reporting guidelines.**

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Conclusion: **Extraforaminal lumbar interbody fusion is a feasible and safe alternative for restoring the L5-S1 disc height with clinical improvement and significant pain control by the use of intradiscal working tubes and bullet-shaped cages,**

Keywords: ELIF, Restore height disc, L5-S1 disc collapsed

1. Introduction

Traditionally L5-S1 disc intervertebral can be approached by different areas described in the literature, such as the anterior, oblique, and posterior approaches. The anterior approach (Anterior Lumbar Interbody Fusion) provides a frontal view of the space under a broad exposure but involves vascular and genitourinary surgical risks, such as retrograde ejaculation [1]. The oblique approach (Oblique Lumbar Interbody Fusion, OLIF) provides direct and extensive exposure to the intervertebral disc space avoiding neural and muscular injuries compared with the posterior approach. However, it is still difficult because of the risks associated with mobilization of the vessels and the presence of the iliac wing [2,13,14]. The lateral approach is not feasible at L5-S1 due to the iliac crest [1,15]. In posterior approaches, the approach to the L5-S1 space is sometimes complex due to the presence of the sacral wing, iliac crest, and the emergence of the L5 root in an almost horizontal position [3–5]. A

Received 15 October 2021; revised 3 February 2022; accepted 3 February 2022.
Available online ▪ ▪ ▪

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ISSN Pending. Published by Mexican Society of Neurological Surgery (Sociedad Mexicana de Cirugía Neurológica A.C.).

collapsed L5-S1 disc has been considered a small space for surgical work, technically complex to recover intervertebral space. A postero-lateral approach such as the Extraforaminal Lumbar Interbody Fusion (ELIF) reaches the Kambin's safety triangle [6], after partial removal of the inferior joint process turning it into a protective shield for the dural sac. The ELIF approach allows the placement of an interbody cage and transpedicular screws through a single wound while avoiding the neural, vascular, and genitourinary risks.

We aim to provide a technical note for ELIF in a collapsed L5-S1 space. We present our experience and results using the Visual Analog Score (VAS), Oswestry Disability Index (ODI), and complications rates. In addition, we provide recommendations for its implementation based on its safety and efficacy.

2. Materials and methods

We collected data from the records of patients who underwent single or multilevel ELIF between March 2020 to June 2021. We retrospectively analyzed those patients who had complete data from the ELIF technique at a collapsed L5-S1 to reduce bias. We included patients with degenerative disc disease, spondylolisthesis, spinal canal stenosis, or foraminal stenosis. We eliminated cases with incomplete files.

We collected data on sex, age, clinical symptoms, diagnosis, the height of the L5-S1 space in the presurgical radiographic images, and the postoperative size of the intervertebral space obtained. In addition, we use the visual analog scale (range 0–10) to assess pain the Oswestry disability index to assess the pre and postoperative clinical-functional condition at one month. We used the SPSS version 26 program for the statistical analysis, and the T-student test was applied, using Box plots to present the results. This observational report adheres to the STROBE guidelines.

3. Results

We reviewed 108 files; we selected and collected information from 29 patients with ELIF to manage a collapsed L5-S1 space; the mean age was 53.9 years with a standard deviation (SD) of 13.2, and 55% [16] of the sample corresponding to women.

The most frequent symptom was axial and radicular pain in 82.8%, with a motor deficit in 27.6% (8 patients). In addition, we had 5 cases (17.24%) with Meyerding grade I spondylolisthesis associated with radiculopathy Table 1.

Abbreviations

ELIF	Extraforaminal lumbar interbody fusión
ALIF	Anterior lumbar interbody fusión
OLIF	Oblique lumbar interbody fusión
TLIF	Transforaminal lumbar interbody fusión
LLIF	Lateral lumbar interbody fusión
PLIF	Posterior lumbar interbody fusión
ODI	Oswestry disability index
VAS	Visual analog scale
PEEK	Poly-ether-ether-ketone
POST OP	Post operatory

Table 2 shows the average pre and postoperative changes in the L5-S1 intervertebral space height, the visual analog scale, and the Oswestry disability index.

The mean initial height was 5.23mm (SD 2.62mm) and a 95% confidence interval (95% CI) of 4.23–6.22mm. The final height reached an average of 11.38mm (SD 1.32mm) and 95% CI of 10.87–11.88mm, reporting a statistically significant difference of 6 mm using a student's t-test (Fig. 1).

The mean preoperative Oswestry disability Index was 42.28 (SD 10.65, 95% CI 41.22–49.32), with a

Table 1. Demographic data.

	N	%
Population	29	100%
Gender		
Female	16	55
Male	13	45
Symptom		
Axial pain	5	17,24
Radicular pain	0	0
Axial and radicular pain	16	55,17
Axial and radicular pain + motor deficit	8	27,59
Diagnosis		
Radiculopathy + spondylolisthesis	5	17,24
Radiculopathy + degenerative disc disease	18	62,07
Degenerative disc disease	5	17,24
Spinal stenosis	1	3,45

Table 2. Radiological and clinical characteristics.

	Mean	Standard deviation (sd)
Height intervertebral space L5-S1 (mm)		
Pre-operative	5,23	2,62
Post-operative	11,37	1,32
Pain visual analog scale (0–10) (VAS)		
Pre-operative	8,51	1,08
Post-operative 1 month	2,41	1,15
Oswestry disability index (100–0) (ODI)		
Pre-operative	45,27	10,65
Post-operative 1 month	15,65	10,28

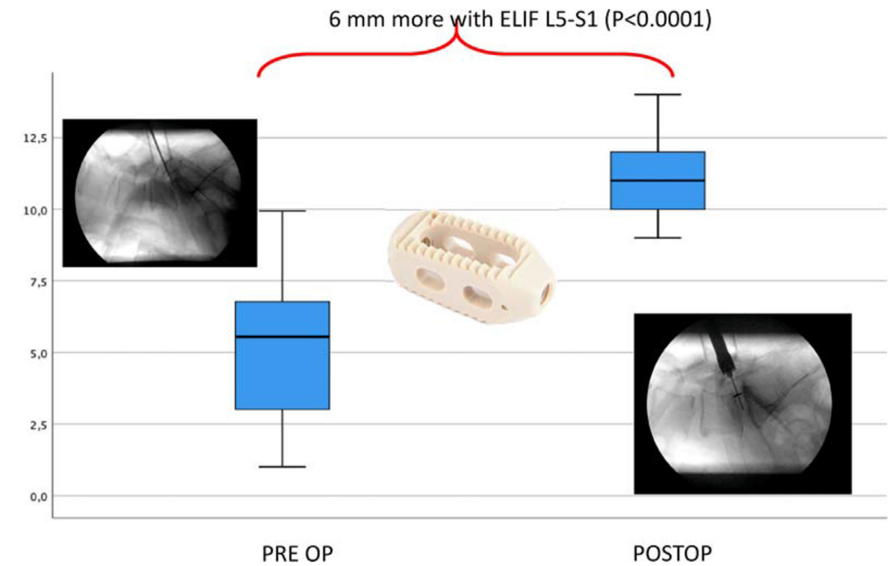

Fig. 1. Comparision height intervertebral space L5-S1 preoperative versus postoperative.

mean 1-month postoperative score of 15.65 (SD 10.28, 95% CI 11.74–19.56), reporting a statistically significant improvement of 29.62 points using a student's t-test (Fig. 2).

The mean preoperative pain by visual analog scale was 8.51 (SD 1.08, CI95% 8.10–8.93), with a mean postoperative score at one month of 2.41 (SD 1.15, CI95% 1.97–2.85), having a statistically significant improvement of 6 points test using a student's T-test (Fig. 3).

None of the patients in our series presented neurological, genitourinary, or vascular complications.

3.1. Description of the surgical technique

We performed the surgical procedures under total intravenous anesthesia with multimodal neurophysiological monitoring (somatosensory potentials, basal motor, and continuous electromyography). We position the patient prone on a Pro axis table, Jackson table, or radiopaque table with lateral rolls to avoid increased intra-abdominal pressure and reduce intraoperative bleeding [16], First, we flexed the patient's hips and knees to maintain lumbar lordosis. Then, we verified any pressure areas so that the anterior superior iliac spines must be free to avoid injury to the lateral femoral cutaneous nerve [17]. Finally, the patient is fixed to the surgical table with an adhesive cloth to avoid movements in the intraoperative period during the rotations of the table; sometimes, we have to give lumbar flexion to the table to open the workspace.

We perform standard surgical cleaning and sterile drapes placement. Next, we marked the midline, the external parapedicular line, and a line 2 cm laterally using fluoroscopy in anteroposterior projection.

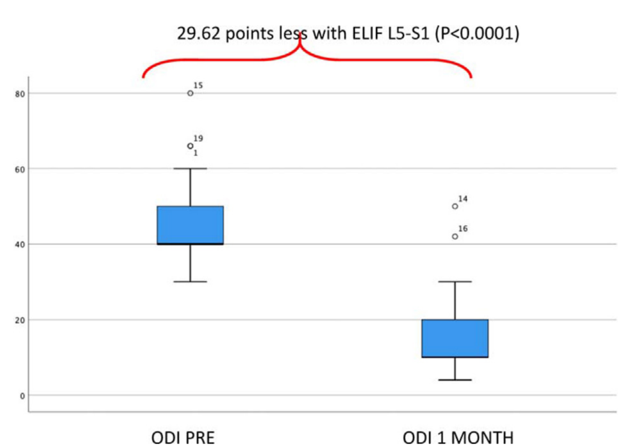

Fig. 2. COmparision odi preoperative versus postoperative at 1 month.

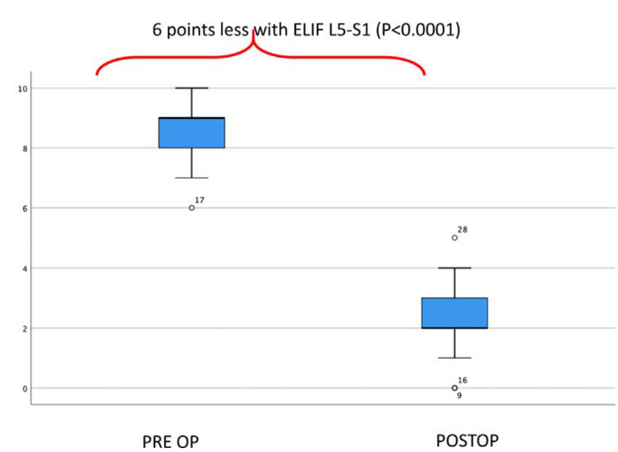

Fig. 3. Comparision VAS preoperative versus postoperative at 1 month.

Next, we marked the height of the pedicle of L5 and S1 in the lateral projection. Skin incisions are usually 2 cm long incisions. Next, we dissected the subcutaneous cellular tissue by planes to open the superficial (Camper's) and the deep (Scarpa's) lumbar fascia. Then we opened the thoracolumbar fascia followed by the fascia of the erector spine muscle to enter the muscular groove between the external aspect of the longissimus muscle and the medial aspect of the iliocostalis muscle [18]. At this point, we performed a blunt cephalo-caudal dissection with the finger at a 45° angle directed to the external pedicle line to reach the facet complexes of L5-S1, as well as the intertransverse spaces and the foramen; where the L5 exiting nerve root is more anterior, horizontal and lateral [17].

We positioned the initial tube with a blunt tip diameter of 5 mm resting on the L5-S1 facet complex. Then we placed the sequential tubular dilators until the definitive tubular retractor fixed it to the articulated arm on the table rail contralateral to the surgeon. Finally, we remove the sequential dilators and verify the final position of the tube on the L5-S1 facet complex under fluoroscopy.

We tilt the surgical table approximately 16° towards the surgeon to verify his ergonomics to avoid risky maneuvers for the patient or the surgeon. Next, we resected the remaining soft tissue on the facet joint under microscopic vision. In the facet joint, the lower facet of the superior vertebra is located medially and the sacrum facet laterally. In addition, using Penfield dissector number 4, we draw the superior edge of the sacral wing laterally, locating the extraforaminal space with the emerging root.

We reamed the lateral facet using a 2 mm matchhead lateral cutter to form a triangular area whose limits are at the base: the sacrum pedicle, the edge of the lateral facet, and a line between the apex of the lateral facet and the sacral wing. This approach allows reaching Kambin's safety triangle, where the ganglion and exit root are located at its superolateral border.

After lateral facetectomy, the fibrous ring is evident in-depth; at this point, we carefully separated the peridiscal vessels from the emerging nerve root and cut them to avoid any bleeding or nerve irritation. Then we performed an annulotomy with partial resection of the disc to insert the bullet-shaped endodiscal dilator. In a true lateral-vie of fluoroscopy, the anterior border of the dilator must coincide with the anterior border of the L5 and S1 vertebra. Therefore, in the AP projection, the anterior edge of the endodiscal dilator must exceed the midline of the disc. Then we completed discectomy through the endodiscal working tube with curettes and disc forceps to expose the bone endplates washing and vacuuming the space to remove residual disc fragments [19], Then, we placed 12.5 ccs of structural bone graft chips and 2.5 ccs of demineralized bone matrix to fill the intervertebral space. Then, we placed a Kirschner wire into a central position on the L5-S1 intervertebral space to guide the cage. Then we removed the endodiscal tubular system and inserted the cannulated bullet-shaped cage into the disc space to restore its height. At this time, we alerted the neurophysiology team and partially inserted the cage with percussion maneuvers. Then, we removed the Kirschner wire and finished insertion as anterior and central as possible regarding the spinous processes on AP fluoroscopic view. Therefore, the anterior tip of the cage should go beyond the midline, achieving anterior support and height to the neuroforamen. Figs. 4 and 5 demonstrate positioning. Note: sometimes, to achieve a proper position of the endodiscal port and cage, it is necessary to extend the bone drilling to the medial facet or even, in a few cases, partially drill the iliac wing [7,20].

After completing cage insertion, we removed any residual disc fragments in the intervertebral disc space or over the cage under the microscopic vision. Next, we verified hemostasis and confirmed the indemnity of nerves confirmed by neurophysiology. Then we removed the tubular retractor and performed muscle hemostasis to proceed with fixation. We placed cannulated, polyaxial, transpedicular screws and bars with a percutaneous technique under radiological vision or neuronavigation (O-arm).

A control scan is performed with O-arm or by fluoroscopy to evaluate the adequate placement of the implants. Finally, we performed hemostasis again, closing the fascia, subcutaneous cellular tissue, and skin by planes.

4. Discussion

Degenerative disc disease is more frequent and severe at the lumbosacral level; due to the strength in the L5-S1 segment and the range of motion, it is susceptible to acute injury or chronic degeneration. Oichi et al. [9], observed a reduced signal intensity at L5-S1 in MRI of 86.0% of participants and decreased disc height in 55.6%.

The anterior and lateral oblique approaches for the L5-S1 space [1,4,21] are associated with complications such as retrograde ejaculation due to manipulation of the hypogastric plexus, visceral injuries, and injuries to the great vessels. For example, Woods et al. [22] reported a vascular

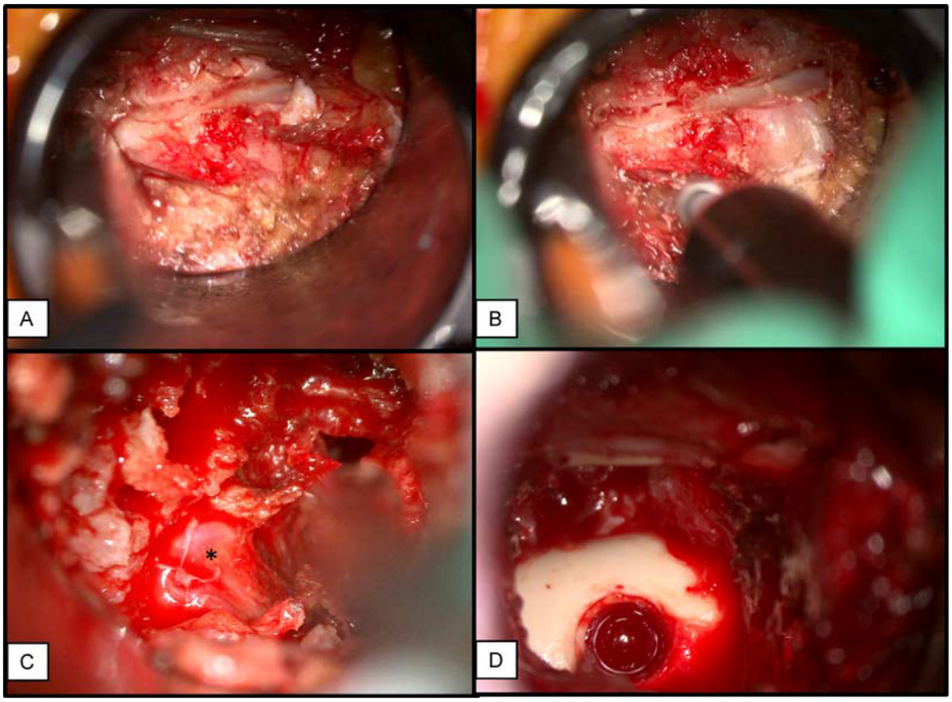

Fig. 4. A. Exposure and visualization of the facet joint. B. Lateral facet drilling to access Kambin's triangle. C. Intervertebral disc exposure and discectomy (exit root). D. Final visualization of the cage in space.*

complication rate in OLIF of 4.3%, while ALIF was 3.3%.

The anatomical limits of the L5-S1 intertransverse space and disc are medially by the superior joint process of S1 and laterally by the sacral wing and iliac crest. The L5-S1 disc space has a caudal inclination due to the sacral anatomy [20]; , making posterolateral approaches challenging. Furthermore, posterior approaches are implicated in the L5 root lesion because it emerges horizontally to the sacral wing; with a collapsed L5-S1 disc space, the working space to the intervertebral disc is severely reduced. We highlight the importance of carefully dissecting muscles from the anterior surface of the transverse processes to avoid arterial vessel injuries in this location that can cause a retroperitoneal hematoma in the postoperative period [16].

In a recent meta-analysis [10] authors compared the anterior versus posterior approach finding no significant difference in fusion rates between ALIF versus TLIF (88.6% vs. 91.9%, P = 0.23). The dural injury was significantly lower in the ALIF group (0.4% vs. 3.8%), while blood vessel injury was significantly higher (2.6% vs. 0%). We detected no differences in neurological deficit (6.8% vs. 7.9%) and infection rates (4.9% vs. 4.3%). In our ELIF cases, the medial facet protects the dural sac and nerves from incidental durotomy, a complication present in posterior approaches, especially in degenerative pathologies of the spine [11,12].

The ELIF technique has multiple advantages. It later enters through a muscular interval between the medial plane's longissimus and the iliocostalis. It allows the integrity of the erector spine muscle in the postoperative period with no evidence of fat atrophy or degeneration on follow-up magnetic resonance imaging at six months [20]. In addition, it allows a lower risk of fibrosis formation between the dural sac and emerging roots by using an extraforaminal working canal at 45° from the midline. It allows posterior decompression of the spinal canal, the lateral recess, and nerve root by performing (if necessary) an extension of resection of the medial facet and resection of the yellow ligament in the same surgical act. The presence of previous abdominal surgeries does not contraindicate ELIF as in anterior and lateral approaches. It avoids genitourinary complications, abdominal viscera, injury to the great vessels, the lumbar plexus, and muscles such as the psoas described for anterior or lateral techniques [1,4].

Our technical description provides tips that make ELIF possible in a collapsed L5-S1 disc space, contrasting this aspect to current knowledge considering ELIF contraindicated. We hope that our technique can make surgeons aware of its benefits when considering a surgical approach for their patients, avoiding the complications of anterior or lateral approaches. However, posterolateral techniques can suffer from the suboptimal cage or screw positioning,

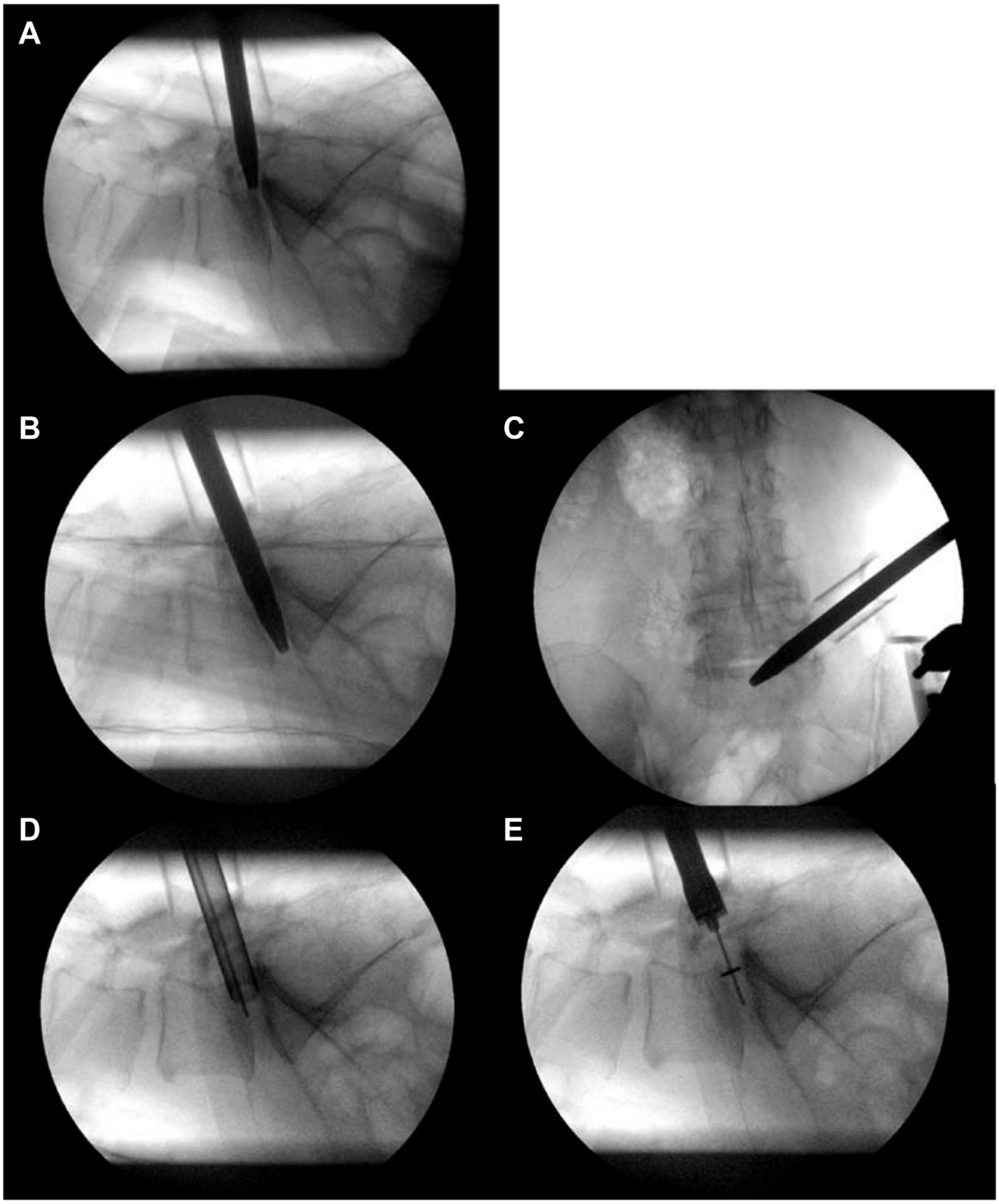

Fig. 5. X-ray transoperative A. Lateral view: tubular retractor with endodiscal dilator. B and C. Endodiscal dilator insertion, lateral and AP view. D. Endodiscal cannula with K-wire insertion. E. Cage insertion with K-Wire.

pseudoarthrosis, radiculopathy, epidural or subdural hematomas, peridural fibrosis [23], radiculitis [17], cerebrospinal fluid fistula, and muscle atrophy with fatty degeneration [8], We recommend performing a meticulous dissection and hemostasis protecting the nerve roots from the heat of bipolar coagulation to help avoid these complications.

The data found in this work show that the ELIF technique can statistically modify the height of the L5-S1 interbody space, as shown in Fig. 2. Additionally, the score of the Oswestry disability index and pain in VAS can be statistically improved, as shown in Figs. 3 and 4. Our data support that ELIF is suitable for this segment rather than an anterior or oblique approach by avoiding significant risks and placing inter somatic cage and transpedicular screws. More than just possible, ELIF is effective in restoring disc height with a wedge technique using an endodiscal dilator, a bullet-shaped guided cage insertion, and extending drilling to the medial facet or the iliac wing in the needed case [7,8].

Our work highlights that it is possible to restore the height of the L5-S1 intervertebral disc space through the ELIF technique with good results while avoiding complications of the anterior or lateral techniques. Our study opens up opportunities to compare with other techniques such as ALIF, TLIF, PLIF, and LLIF, even in the future to evaluate merger rates and the risk of subsidence of the cages, angles of segmental and global lordosis. Our main limitation is the small sample and that we did not evaluate patients' comorbidities, although it was not the purpose of this research; long-term follow-up is also required. Our research did not present conflicts of interest and was not funded.

5. Conclusion

Extraforaminal lumbar interbody fusion is not a contraindication for a collapsed L5-S1 intervertebral disc space. In fact, according to our results, it is a safe surgical alternative that effectively restores the intervertebral height. In addition, it requires the use of an endodiscal tubular dilator shaped like a blunt pen and bullet cages. Good clinical results support its use avoiding unnecessary hazards from other techniques.

Funding disclosure(s) statement

We have neither Conflict of Interest nor any financial relationship to disclose.

We have no other funding to disclose other than authoŕs own.

Acknowledgment

Thanks to our surgical team Dr. Enrique Flores Soria, Dr. Danahe Díaz Franco, anesthesiologists, Dr. Oscar Sanchez Escandon, neurophysiologist and, Lic. Herendira Gaspar, surgical instrumenter.

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Archives of Neurosurgery

Volume 1 | Issue 2 Article 9

2020

Innocuous expectoration of an anterior C3 loosened screw—case report and literature review about a benevolent evolution with no esophageal injury

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ARCHIVES OF NEUROSURGERY REVISTA DE DIVULGACIÓN CIENTÍFICA DE LA SOCIEDAD MEXICANA DE CIRUGÍA NEUROLÓGICA A.C., Año 1, No.2 (enero a junio 2022) es una publicación cuatrimestral editada por la Sociedad Mexicana de Cirugía Neurológica A.C., Miami 47, Nápoles, Benito Juárez, 03810 Ciudad de México, CDMX, Tel 52 (55) 5543 0013, https://www.ansjournal.org. Editor: Fiacro Jiménez Ponce. Reserva de Derechos al Uso Exclusivo No. 04-2023-051212055700-102, ISSN: En trámite, ambos otorgados por el Instituto Nacional del Derecho de Autor. Responsable de la última actualización de este número Fiacro Jiménez Ponce, Miami 47, Nápoles, Benito Juárez, 03810 Ciudad de México, CDMX, fecha de última modificación 22 de junio del 2022.

Innocuous expectoration of an anterior C3 loosened screw—case report and literature review about a benevolent evolution with no esophageal injury

Abstract

The anterior cervical discectomy and fusion (ACDF) technique is the gold-standard treatment for myeloradiculopathy. We present the case of a seventy-five years old female who came to revision because of worsening solids dysphagia, dry cough, and foreign body sensation in the past two weeks; we had practiced her an ACDF procedure four years ago. She denied presenting neurological deficit or neck pain. The physical examination was normal. Cephalic migration of the left C3 screw was evident on cervical plain and dynamic films and CT-Scan. She was admitted to the hospital for an upper gastrointestinal endoscopy that visualized retropharyngeal ulceration. Thirty minutes before surgery, she presented a spontaneous cough reflex and expelled the screw through her mouth; An esophagogram with a swallow of Bario showed no leakage of the contrast medium. She was under hospital surveillance for five days with prophylactic parenteral nutrition, progressing to a soft diet and later a regular diet. She was discharged home without a new surgery.

Cervical screw loosening has been reported as a rare complication, either due to poor placement or due to the patient's osteoporosis. This case report describes an innocuous spontaneous expectoration of a C3 loosened screw and the diagnostic, therapeutic approach we carried after this event.

Visual Abstract

Keywords

Anterior cervical discectomy and fusion (ACDF), hardware migration, hardware complications, cervical spine surgery

Authors

Gerson Reyes Rodriguez, José Alberto Israel Romero Rangel, Manuel Soto García, Manuel Rodriguez Garcia, Victor David Lopez Garcia, Iris Tatiana Montes González, and José Antonio Soriano Sánchez

Innocuous Expectoration of an Anterior C3 Loosened Screw—Case Report and Literature Review About a Benevolent Evolution with No Esophageal Injury

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Abstract

The anterior cervical discectomy and fusion (ACDF) technique is the gold-standard treatment for myeloradiculopathy. We present the case of a seventy-five years old female who came to revision because of worsening solids dysphagia, dry cough, and foreign body sensation in the past two weeks; we had practiced her an ACDF procedure four years ago. She denied presenting neurological deficit or neck pain. The physical examination was normal. Cephalic migration of the left C3 screw was evident on cervical plain and dynamic films and CT-Scan. She was admitted to the hospital for an upper gastrointestinal endoscopy that visualized retropharyngeal ulceration. Thirty minutes before surgery, she presented a spontaneous cough reflex and expelled the screw through her mouth; An esophagogram with a swallow of Bario showed no leakage of the contrast medium. She was under hospital surveillance for five days with prophylactic parenteral nutrition, progressing to a soft diet and later a regular diet. She was discharged home without a new surgery.

Cervical screw loosening has been reported as a rare complication, either due to poor placement or due to the patient's osteoporosis. This case report describes an innocuous spontaneous expectoration of a C3 loosened screw and the diagnostic, therapeutic approach we carried after this event.

Keywords: Anterior cervical discectomy and fusion (ACDF), Hardware migration, Hardware complications, Cervical spine surgery

1. Introduction

The Anterior cervical discectomy and fusion (ACDF) is the gold standard for treating myeloradiculopathy. Its main indications are anterior compression vector, lower than three segments compromise, loss of cervical lordosis, disc-osteophyte complex, and ossification of the posterior longitudinal ligament [1−4, 12−14]. It allows a direct decompression, arthrodesis stabilization, lengthening of the cervical spine, and even more significant neurological improvement in the following five years after surgery [22,23]. Early complications include postoperative dysphagia, hematoma, dural tear, recurrent laryngeal nerve injury, Horner's syndrome, and esophageal perforation. Late complications to consider are hardware failure, pseudoarthrosis, and even hardware migrations [5−8].

There are reports on cervical screw loosening among the rarest complications that tend to happen in the mediate term due to poor placement or osteoporosis. Moreover, even a single report of a C2−C3 entire construct expectoration exists [9]. This case report describes a C3 loosened screw innocuous spontaneous expectoration, the diagnostic and therapeutic approach we carried out after this event.

Received 18 October 2021; revised 14 November 2021; accepted 19 February 2022.
Available online ■ ■ ■

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ISSN-Pending. Published by Mexican Society of Neurological Surgery (Sociedad Mexicana de Cirugía Neurológica A.C.).

2. Representative case

We present the case of a seventy-five years old female who came to revision in June 2020 because of worsening solids dysphagia, dry cough, and foreign body sensation in the past two weeks; we had practiced her an ACDF procedure four years ago (Fig. 1).

She denied presenting neurological deficit or neck pain. The physical examination showed no pain on active movements of the cervical spine; his strength was symmetrical in 4 extremities, without sensory alterations or abnormal reflexes. Cephalic migration of the left C3 screw was evident on cervical plain and dynamic films and CT-Scan. The remaining C3−C7 cervical construct demonstrated intervertebral fusion, preserved lordosis, and no neural compression. The screw was located in the retropharyngeal space at the glottis level in the sagittal plane and behind the medial and inferior pharyngeal constrictor muscle. She was admitted to the hospital for an upper gastrointestinal endoscopy that rule out esophageal perforation, reporting epiglottis ulceration and non-erosive gastritis. She was scheduled for revision cervical spine surgery to remove the screw in the evening shift. Thirty minutes before surgery, she presented a spontaneous cough reflex and expelled the screw through her mouth with no bleeding traces in the screw or the oropharynx (Fig. 2). An esophagogram with a swallow of Bario showed no leakage of the contrast medium. We observed a hypointense halo in a new CT scan where the cervical screw was previously hosted (Fig. 3). She was under hospital surveillance for five days with prophylactic parenteral nutrition because of a lack of scientific evidence in this context; later, she started a liquid diet with progression to a soft diet and later a regular diet without other symptoms. She was discharged home without a new surgery (Fig. 4 Timeline of events).

Abbreviations

ACDF	Anterior Cervical Discectomy and Fusion
C	Body of the corresponding cervical vertebrae
MRI	Magnetic Resonance Imaging
CT	Computed Tomography

3. Discussion

The anterior cervical discectomy and fusion (ACDF) is a surgical procedure, first described by Smith and Cloward in 1955, performed widespread globally [1,10]. Cervical spinal surgery treats various pathologies such as spondylosis, neoplasms, infections, and trauma [11]. Complications for anterior cervical approaches range between 1.6 and 31.3% of the cases, including neurological, vascular, esophageal injury, dysphagia, dysphonia, respiratory distress, implant-related complications, adjacent segment degeneration, cerebrospinal fluid leakage, infection, and Horner's syndrome [12−14,24,25]. Cervical screw loosening has been reported as a rare complication due to poor placement or to the patient's osteoporosis. Pharyngoesophageal perforations can occur intraoperatively, perioperatively, or several years later, with a low incidence of 0.25%−1.49% [13,14].

The esophageal lesion presents in 0.3%−4% and is considered an early complication when it appears 30 days after surgery and late after this period. Plaque or screw migration is the most common cause of late esophageal injury, with mortality ranging from 7% to 27−60% when the diagnosis is late. Screw migration as a late complication has been reported

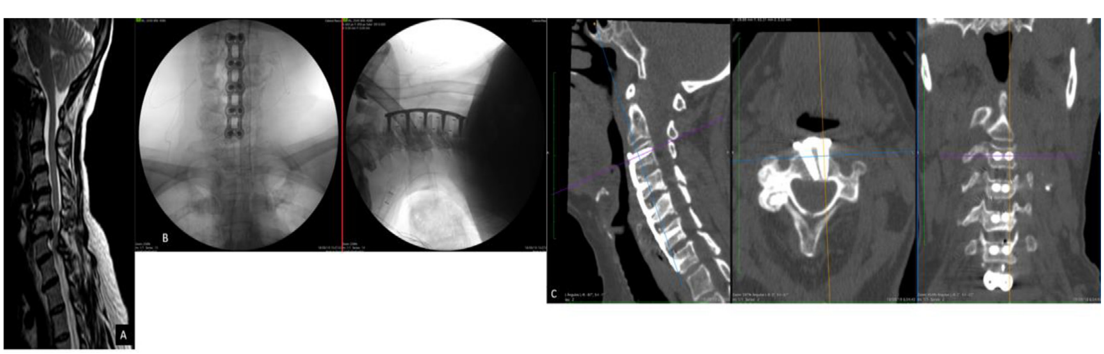

Fig. 1. Image A shows the initial MRI before anterior cervical instrumentation that was performed due to cervical spondylotic myelopathy from C3−C7. Image B shows the final construct and realignment of the cervical lordosis in the projections AP and lateral postoperative. Image C shows the cervical spine simple tomography in the bone view where the proper placement of the C3 cervical screws in multiplanar reconstruction is observed.

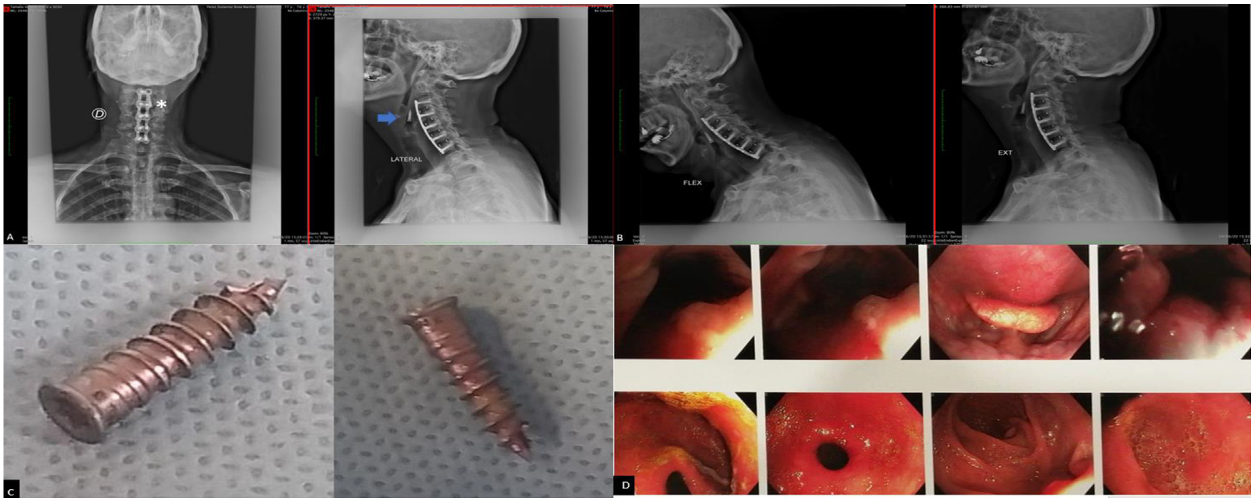

Fig. 2. Image A, the migration of the cephalic left cervical screw is observed in the anteroposterior projection radiograph shown in figure | , and in the lateral radiography, the migration of the screw is mainly in the retropharyngeal space of 5 mm shown on the arrow. Image B shows the dynamic films in flexion and extension, demonstrating construct fixation with no instability. Image C shows the cervical screw spontaneously expelled through the upper airway 30 without leaving any clinical sequelae. Finally, figure D shows endoscopy images without perforation of the hypopharynx and esophageal walls is observed.

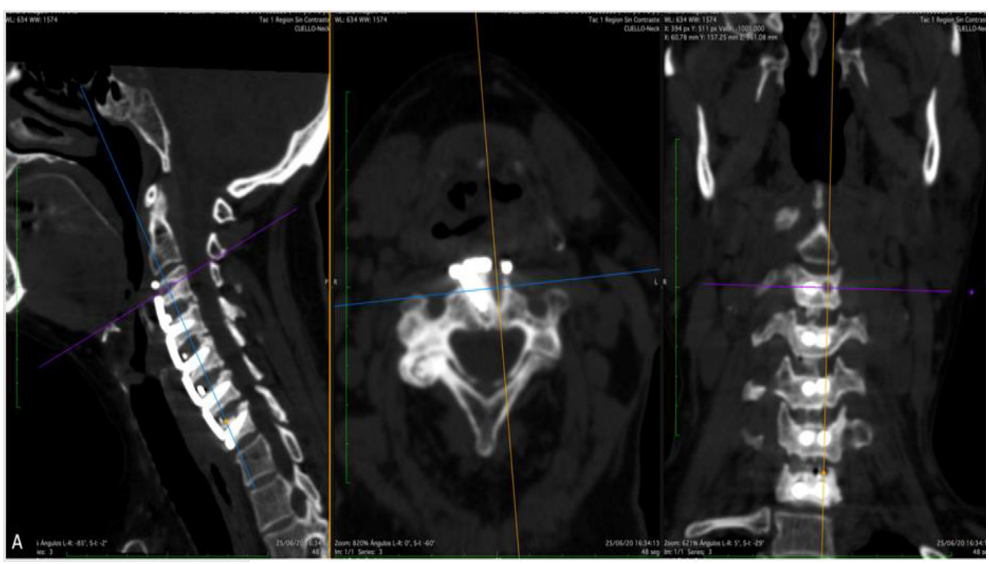

Fig. 3. Image A shows a multiplanar reconstruction with the absence of the left C3 cervical screw after the expulsion of the screw.

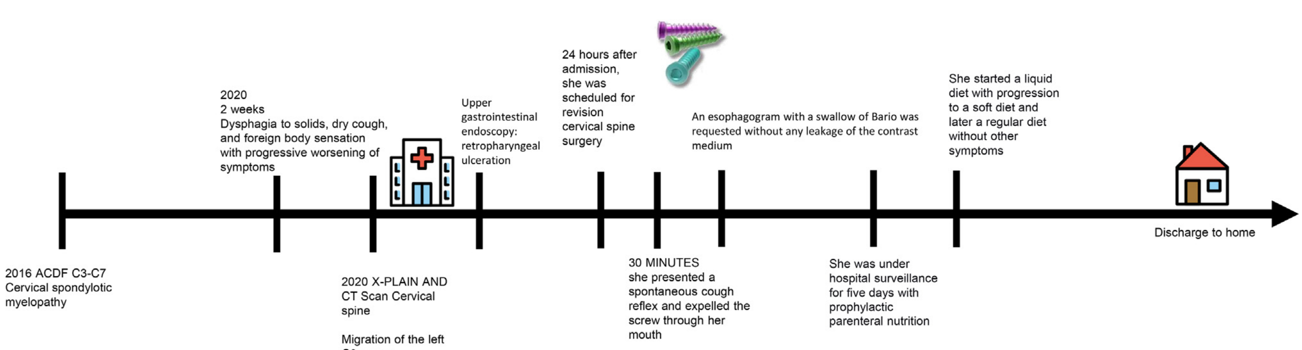

Fig. 4. Timeline of the events.

in up to 35% of cases, considered the most common cause of pharyngoesophageal injury secondary to cervical fusion. Esophageal perforation is the primary concern about spontaneous hardware expulsion. The proposed mechanisms for esophagopharyngeal perforation are pressure ulcers caused by the metal implant microtrauma. Chronic compression of the posterior pharyngoesophageal wall either by bone or the fixation device leads to focal ischemia, resulting in an esophageal perforation. The literature has some cases of loosened screws found in the gastrointestinal tract without evidence of scarring or ulcers. In such cases, the esophageal perforation has probably healed without clinical complication. Therefore, we must consider the loosening of anterior cervical screws a risk factor for esophageal perforation. Migration of the screw or construct parts in the cervical region can lead to hardware aspiration, mediastinitis, and even dead [5–7,15–17].

Concerning the innocuous expulsion presented in our case, we would like to mention some anatomical considerations that might have helped for a harmless passage of the screw. One key anatomical aspect is the Killian's triangle, which is formed by the union of the lower border of the inferior pharyngeal constrictor muscle and the superior border of the cricopharyngeal muscles. This region is usually anterior to the C5–C6 disc space and, on certain occasions, more cranial. It is mainly a weak area of the esophageal wall with a high predisposition to form Zenker's diverticula. This thin oropharyngeal layer separates the retropharyngeal space from the esophagus [18], allowing surgical retraction injuries. Nevertheless, in our case, we consider that this relationship of the Killian's triangle anatomy provided an esophageal harmless expulsion corridor for the screw to go through.

Our case highlights the lack of symptoms; the patient only had mild dysphagia for two weeks before spontaneous expectoration.

Many authors have reported their experience in late pharyngoesophageal perforations with hardware failure and spontaneous healing. Spontaneous healing may result from the small size of the displaced instrument or its slow postoperative migration. For example, Xing found that screws loosened by 2–5 mm can be managed conservatively with a cervical collar for three months to attain fusion. However, migration of more than 5 mm of the screws is associated with a high risk of injury to neighboring structures [19,20].

Asymptomatic patients without any infection around the perforated site often heal spontaneously and do not require surgical treatment. Therefore, after conducting this review of the medical literature, we encourage surgeons to be aware of Killiam's triangle anatomy, representing a passage through which migrated devices can go through the airway and be expelled, given its thin wall nature. We also consider that ulceration occurred in the hypopharynx through the Killiam's triangle and not in the esophagus wall below C5, which is also probable for the case report of a complete expulsion of the C2–C3 hardware.

It is mandatory always to carry out relevant studies such as simple cervical spine tomography, cervical MRI, and barium esophagram to rule out any complication that may increase mortality in a patient with this type of pathology. It could be an anatomical protective factor for only giving medical management to these patients and knowing that pharyngeal perforations can also occur and are more benign than esophageal perforations. Any migrated device beyond 5 mm in length in the cervical region must have revision surgery to avoid complications such as mediastinitis, esophageal perforation, or even dead [21].

Funding

We don't have any interest conflict and any funding sources.

4. Conclusions

Spontaneous innocuous expectoration of a cervical screw is not frequently observed and can be challenging for decision-making both for the patient and the surgeon for its conspicuous appearance. A benevolent course can often be expected for hardware migrating from C3–C5 levels due to Killian's triangle avascular anatomy. Nevertheless, all the patients must be provided with diagnostic tests to rule out complications, including esophageal perforation.

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ARCHIVES OF NEUROSURGERY

Archives of Neurosurgery

Volume 1 | Issue 2 Article 10

2020

Clinical Applications Of Direct Cortical Stimulation During Awake Craniotomies. Commentary On Passive Functional Mapping Using Infrared Thermography In Epilepsy Awake Surgery.

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ARCHIVES OF NEUROSURGERY REVISTA DE DIVULGACIÓN CIENTÍFICA DE LA SOCIEDAD MEXICANA DE CIRUGÍA NEUROLÓGICA A.C., Año 1, No.2 (enero a junio 2022) es una publicación cuatrimestral editada por la Sociedad Mexicana de Cirugía Neurológica A.C., Miami 47, Nápoles, Benito Juárez, 03810 Ciudad de México, CDMX, Tel 52 (55) 5543 0013, https://www.ansjournal.org. Editor: Fiacro Jiménez Ponce. Reserva de Derechos al Uso Exclusivo No. 04-2023-051212055700-102, ISSN: En trámite, ambos otorgados por el Instituto Nacional del Derecho de Autor. Responsable de la última actualización de este número Fiacro Jiménez Ponce, Miami 47, Nápoles, Benito Juárez, 03810 Ciudad de México, CDMX, fecha de última modificación 22 de junio del 2022.

Clinical Applications Of Direct Cortical Stimulation During Awake Craniotomies. Commentary On Passive Functional Mapping Using Infrared Thermography In Epilepsy Awake Surgery.

Abstract

As clinicians, we rely on various imaging methods to identify abnormal brain lesions. We can distinguish this myriad of neurological disorders by using imaging alone or together with either or both electrophysiological monitoring and direct cortical stimulation. This last alternative is the most frequently used approach to diagnosing brain lesions requiring awake craniotomies for adequate management. Awake craniotomies have become the standard of care for focal lesions, including vascular malformations like cavernous angiomas, intrinsic brain tumors, gliomas, vasculitic brain lesions, postinfectious brain lesions, brain metastasis, and also for epilepsy surgery. Surgery for epileptic patients requires multidisciplinary team interactions and a variety of surgical adjuncts. The clinical decision-making proceeds with a specific protocol following a rigorously defined technique for awake craniotomies. Using a systematic approach affords a reliable and reproducible method for epilepsy treatment while avoiding postoperative complications. While direct cortical stimulation remains the mainstay for postoperative neurological deficit evaluation, there is undoubtedly a need for new technologies that can help increase the sensitivity and specificity of abnormal findings and thus help management decisions.

Visual Abstract

Keywords

Awake cranitomy, image-guided craniotomy, frameless approach, cortical stimulation

Cover Page Footnote

Conflict of Interest: None Sources of Funding: Funding was not necessary during the preparation of the manuscript.

Authors

Ramiro Antonio Perez de la Torre, Ramanathan Siddarth, Pérez Ramírez Pedro, and Santiago Noé

Clinical Applications of Direct cortical Stimulation During Awake Craniotomies. Commentary on Passive Functional Mapping Using Infrared Thermography in Epilepsy Awake Surgery

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Abstract

As clinicians, we rely on a variety of imaging methods to identify abnormal brain lesions. The myriad of neurological disorders that we can encounter can be distinguished by using imaging alone, imaging along with electrophysiological monitoring, or imaging with electrophysiological monitoring and direct cortical stimulation. This last alternative is the most frequently used approach to diagnose brain lesions that require awake craniotomies for adequate management. Awake craniotomies have become the standard of care for focal lesions including vascular malformations, such as cavernous angiomas, intrinsic brain tumors, such as gliomas, vasculitic brain lesions, postinfectious brain lesions, brain metastasis and epilepsy surgery. Surgery for epileptic patients requires the interaction of a multidisciplinary team along with the use of a variety of surgical adjuncts. Clinical decision-making proceeds along a specific protocol following a rigorously defined technique for awake craniotomies. The utilization of a systematic approach to avoid postoperative complications makes awake craniotomy a reliable, reproducible and precise methodology for the treatment of epilepsy. While direct cortical stimulation remains the mainstay of evaluating for potential postoperative neurological deficits, there is certainly a need for new technologies that can help increase the sensitivity and specificity of abnormal findings, and thus inform management decisions.

Keywords: Awake craniotomy, frameless approaches, stereotactic neurosurgery

1. Introduction

The clinical method to identify an abnormal neurological sign or a pathognomonic symptomatology is of paramount importance during the initial evaluation of all neurological conditions. Brain imaging is required in order to distinguish brain lesions and identify the intracranial location of the lesions. In many regions, encountering multiple brain lesions is not uncommon. In developing countries, where neurocysticercosis is endemic, as high as 15–20% of the population may display abnormal stigmata that can be further elucidated on imaging. During the initial diagnostic approach, multiple brain lesions can be found that correlate with symptomatic presentation.

Vascular lesions include giant brain aneurysm, cavernous angioma, venous angioma and a variety of other vascular lesions. Tumors include intrinsic tumors, such as meningioma, wherein symptoms generally correlate reasonably well with tumor location, or gliomas that can be present in different regions in the brain showing no symptoms or present acutely, sometimes necessitating urgent decompressive craniotomy. The presentation and imaging characteristics of extrinsic tumors, such as brain metastasis, vary depending upon the site of origin and the location of metastatic brain lesions. Metabolic disorders represent several derangements with characteristic imaging signaling on specific MRI sequences that can be difficult to diagnose clinically. Infectious disorders encompass bacterial, viral and

Received 9 May 2022; revised 11 May 2022; accepted 11 May 2022.
Available online ■ ■ ■

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ISSN Pending. Published by Mexican Society of Neurological Surgery (Sociedad Mexicana de Cirugía Neurológica A.C.).

Archives of Neurosurgery
2022;xx(xx):1–3

fungal brain lesions that sometimes require diagnostic imaging series to identify the causative pathogen. The standard of care for abnormal focal lesions should generally consist of an initial imaging procedure followed by stereotactic brain biopsy to define and diagnose the underlying etiology [1,2]. Once the final diagnosis is made, the specific methodology for lesion resection can be addressed [1–3].

Awake craniotomy has become the standard of care when treating brain lesions proximal to or within eloquent areas or for patients suffering from epilepsy [3]. Awake craniotomy requires a thorough planning procedure that must be addressed preoperatively utilizing MRI and metabolic studies such as SPECT, PET and/or Functional MRI (fMRI) to adequately target the underlying lesion [4–6]. Once the planning process has been completed, the surgical plan can be followed. Immediately prior to the surgery, a specific protocol ought to be followed, including an initial electrocorticography to record the baseline characteristics of the treatment site. In some centers evoked potentials can be utilized to identify the motor strip, direct cortical and subcortical stimulation can be done using commercially available stimulators to identify afterdischarges that may herald postoperative complications [1,2,7]. The surgical technique is meticulous due to the necessity of identifying the abnormal areas correlated with the presenting pathology and removing the lesion without causing postoperative deficits. The identification of inactive lesions has been explored utilizing a variety of techniques. In this paper, the authors describe a simple methodology utilizing thermography to identify abnormal regions using surface temperature and the creation of an imaging protocol of the aberrant margins. This case represents an excellent opportunity to make use of the advantages inherent in the awake craniotomy due to the proximity of the speech areas and the motor areas for the face and the right hand. The protocol that has been described in this paper can be considered a surgical adjunct that may improve our level of understanding of the operative region and can be leveraged in the decision making for such complex cases. This approach can also be improved and continuously analyzed to improve surgical utility in the future. In this paper, the authors describe a hyperemic response at the center of the lesion. From the surgical standpoint, increased temperature is not simply a tissue specific response; the surgical arena is dynamic, with the use of surgical lights, normal saline irrigation to adequately clean the surgical field, and iced water to halt epileptic responses. A normal physiological response to direct cortical stimulation may also lead to increased temperature of the stimulated region and within the lesion itself. As such, the methodology described in this report is able to distinguish between these various responses due to the relative temporality of the thermographic procedure.

1.1. *Avoidance of postoperative deficits*

Instrumentation during awake craniotomies for lesion removal is critical in avoiding postoperative complications. Multiple classifications exist in trying to define the possibility of an increased neurological deficit that may present after complete lesion removal [8]. Multiple studies over have addressed the importance of critical structures in the surrounding region that may show minimal signs but can lead to neurological deficits after resection. In some lesions, multiple regions may be involved with concomitant involvement of subcortical structures. Some centers have been able to use subcortical stimulation to define the extent and proximity of multiple tracts. In the last decade, neurosurgeons have had tremendous opportunity to import functional MRI into the complex schema of awake cranial surgery [4–6]. There are a myriad of publication on the utilization of this technology to better define the proximity of tracts relative to lesions. During the direct cortical stimulation, multiple methods are already in use trying to better define sensory, motor and speech areas. Potentially the most complex decision making arises when handling the speech process. While functional MRI (fMRI) may replace some of the techniques already described, direct cortical stimulation remains the standard of care when managing lesions in these regions. It is possible that the continued investigation and implementation of imaging in awake craniotomies will develop into a simple methodology that can track changes in real time and hasten monitoring without requiring the patient to sit fixed for long periods of time. Intraoperative ultrasonography, intraoperative magnetic resonance imaging, and intraoperative brain tomography can be conducted within the span of minutes along to directly monitoring specific areas. New technologies can be simultaneously be applied to monitor abnormal regions, potentially increasing the sensitivity and specificity of any abnormal findings.

1.2. *New methodologies*

We strongly believe that, at this juncture, the most reliable surgical methodology to define abnormal regions is direct cortical stimulation along with direct subcortical stimulation to rule out postoperative neurological deficits. We congratulate the authors for their courage to include new technologies in the surgical management of complex lesions.

2. Conclusions

The surgical management of abnormal brain lesions is a complex interaction of available resources and surgical adjuncts to better define the margins and the physiological correlation during the process of resection. New technologies are welcome to improve our complex understanding in this critical process.

Sources of funding

Funding was not necessary during the preparation of the manuscript.

Conflict of interest

None.

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