Traumatic frontal lobe lesions in miners working at Montes de Triano in the late 19th century

A. García-Molina^{1,2}, A. Enseñat-Cantallops^{1,2} ¹Institut Guttmann. Universitat Autònoma de Barcelona, Badalona, Spain. ²Universitat Autònoma de Barcelona, Cerdanyola del Vallès, Spain.

ABSTRACT

Extensive evidence is available today of the association between lesions to the prefrontal circuits and cognitive impairment; this was not the case in the late 19th century, however. This study aims to present the contributions to this topic made by Dr Enrique Areilza Arregui between 1881 and 1898. During his days as the director of the Miners' Hospital of Triano, Areilza had the opportunity to study and describe the behavioural effects of traumatic lesions to the frontal lobe. In 1887, Areilza published *De las fracturas del cráneo y de la trepanación*, a monograph describing the cases of 27 patients with traumatic brain injuries, 7 of whom had frontal lobe lesions. In his 1899 article "El delirio en las fracturas de la base del cráneo", Areilza not only describes the patients' behaviour but also reports experiments he conducted with one of the patients due to the peculiar characteristics of the case. Areilza's observations in miners working in Montes de Triano, a mountain range in the Basque Country, constitute one of the first clinical contributions to the functional study of the frontal lobe.

KEYWORDS

19th century history, brain damage, frontal lobe, mining, neuroscience, neurosurgery

Introduction

Montes de Triano is a mountain range located in the northwest of Biscay, in the Basque Country. For centuries, the range has been famous for being the site of one of the most important iron mines in southern Europe. As early as in the first century AD, Pliny the Elder referred to a wonderful mountain of iron beside the Cantabrian sea. Mining activity was constant for hundreds of years, but it was not until the last third of the 19th century that mining began on an industrial scale. By the second decade of the 20th century, the iron ore bodies began to show signs of exhaustion; the last mine of the site, Bodovalle, was closed in 1993. Altos Hornos de Vizcaya, the main company in the Montes de Triano ferrous metallurgy industry, closed its doors three years later.¹

Corresponding author: Dr Alberto García-Molina E-mail: agarciam@guttmann.com Between 1876 and 1914, the golden age of exploitation at Montes de Triano, working conditions in the mines had a considerable impact on miners' health. The most frequent diseases were scabies, pneumonia, influenza, and bronchitis. In addition to these conditions, patients also experienced numerous accidents (trolley derailments, rock falls, landslides, poorly controlled blasting, etc.). In view of the above, the owners of the mines at Montes de Triano created the Association of Miners' Hospitals of Montes de Triano in 1880.²

The Miners' Hospital of Triano opened its doors the same year in Cerro de Buenos Aires, in the village of Gallarta. Two hospices were later created in Matamoros (in the old miners' village of La Arboleda) and El Cerco (in the village of Galdames); these were converted into hospitals in 1896. Management of the miners' hospital complex

Received: 4 September 2017/ Accepted: 8 November 2017 © 2017 Sociedad Española de Neurología was entrusted to a young physician from Bilbao, who was barely 20 years old.

Development

Dr Enrique de Areilza Arregui was born on 6 February 1860 on Calle San Francisco in Bilbao (Figure 1).³ He moved to Valladolid to study medicine (1876-1879), and furthered his studies on surgery and clinical medicine as an intern at the La Charité and La Pitié-Salpêtrière hospitals in Paris. After receiving his doctorate from the Faculty of Medicine of the Central University of Madrid, he returned to Bilbao in 1880 and became the first director of the Miners' Hospital of Triano, where he worked for two decades as a surgeon and researcher. He left his position in 1900 and inaugurated the Sanatorium of Bilbao on Calle Gordoniz in 1902. Areilza directed the Hospital de Basurto, also in Bilbao, between 1918 and 1926. While working there, he attempted to create a Faculty of Medicine at the hospital, but the project was paralysed by the Primo de Rivera dictatorship. Concerned about paediatric tuberculosis, Areilza worked shoulder to shoulder with Drs Larrinaga and Llano to create the Marine and Heliotherapy Sanatorium in Gorliz (Biscay), which was inaugurated on 29 June 1919. Areilza died in Portugalete, Biscay, on 14 June 1926. The renowned surgeon José Ribera y Sans (1852-1912) described Areilza as "the most distinguished contributor to craniocerebral surgery in Spain."4

While working at the Miners' Hospital of Triano, Areilza displayed an interest in the frontal lobe and its association with higher brain functions. The Miners' Hospital of Triano was an exceptional setting for the study of frontal lobe injuries, given the characteristics of the patients treated at the hospital and the high incidence of cases. The purpose of this study is to present the contributions made by Dr Areilza to the study of frontal lobe injury between 1881 and 1898.

De las fracturas del cráneo y de la trepanación (1887)

The monograph *De las fracturas del cráneo y de la trepanación*⁵ (Treatise on skull fractures and trepanation) was published in 1887; the text is divided into two parts. The first part, titled "A presentation of the facts," describes 27 cases of traumatic brain lesions. The second, titled "Deductions," analyses these cases and aims to answer two questions: 1) How did the study of head trauma contribute to the doctrine of localisation? and 2)



Figure 1. Enrique Areilza Arregui (1860-1926)

How did cerebral localisation contribute to trepanation in patients with head trauma? The book includes an appendix presenting two additional cases. The present study focuses on the descriptions of patients with frontal lobe lesions.

Observation no. 2

S.R., a 22-year-old man, was hit by several rocks after the blasting of a drill hole on 9 August 1882. He exhibited left frontal lobe lesions, more specifically in the middle and lower thirds of the precentral gyrus and the posterior part of the middle and inferior frontal gyri. The patient experienced no concussion, and displayed right hemiparesis and language impairment (Broca aphasia).

Areilza lifted the depressed bone fragment to decompress the area, after which S.R. progressively recovered mobility and language ability. Eight days after the procedure, the patient's symptoms had completely resolved.



Figure 2. Observation no. 11. T-shaped post-surgery scar

Observation no. 4

On 31 March 1883, a large rock blown from an explosion hit M.M., a 17-year-old miner. The resulting lesion involved both frontal lobes, although the right hemisphere was more severely affected. When M.M. arrived at the hospital, he was in a stuporous condition and was unable to answer any questions. He constantly moved his arms, attempting to touch his head.

The day after admission, the patient underwent decompressive surgery; multiple bone fragments were removed from the brain. After the procedure, M.M. was able to answer questions, though with difficulty. On the third day after the accident, his level of consciousness decreased; the patient went into coma and died the following day. The autopsy revealed extensive damage to the superior and middle frontal gyri.

Observation no. 6

M.A., a 50-year-old man, was hit by a stone on 3 December 1883 and collapsed to the ground. Several minutes later, he regained consciousness and talked with his workmates for a short while. Soon afterwards, M.A. began to shout and recite the Lord's Prayer and the Hail Mary for the soul of his grandfather, Tomás; he repeated the prayers incessantly and monotonously. He had a contusion in the middle and superior frontal region, involving the middle and upper thirds of the superior frontal gyri, especially in the internal area.

The following day, the patient continued to be in a state of delirium, reciting the same prayers aloud. He underwent surgery; after the procedure, the confusional state partially resolved and M.A. was able to answer questions, with some mistakes. Four days after the accident, he was completely lucid. Two days later, however, the delirium returned and the patient began praying aloud once more. That night, he went into coma and died.

Observation no. 11

On 15 July 1885, a 22 year-old miner named J.A. was hit on the forehead by an ore fragment following the blasting of a drill hole. He had no concussion and his mental faculties were preserved. The impact caused lesions to both superior frontal gyri.

Twelve days after the accident, the patient displayed a small pulsatile abscess below the scar. Given the patient's good general health, he was not easily convinced to undergo trepanation to remove the agent causing the abscess (Figure 2). In early September the patient had recovered completely.

Observation no. 12

A.G., aged 40 years, was hit by a stone on 13 August 1885; the miner lost consciousness for several seconds, but travelled to hospital by his own means. The lesion involved the posterior third of the left middle frontal gyrus. The patient was discharged on 1 September, displaying no cognitive impairment.

Observation no. 20

On 25 March 1882, A.F., a 45-year-old man, suffered a concussion after the car he was driving crashed into a rock. He displayed a wound on the left side of his forehead. The wound was dressed and the miner returned to his normal life, experiencing no disabling alterations. Physicians did not deem it necessary to operate on the patient to lift the bone, which was compressing the middle part of the middle frontal gyrus and part of the inferior frontal gyrus.

Seven months after the accident, the patient began to experience vertigo, without losing consciousness. Eleven months after the accident, A.F. suddenly collapsed to the ground and was in coma for over two hours. He progressively recovered consciousness but was left with considerable cognitive impairment and mild language impairment. Fifteen days later, he lost consciousness again, and the cognitive and language impairment worsened. The patient displayed paraphasia and anomia in spontaneous speech, and reading and writing impairment.

Areilza made his first visit with A.F. at this time. He diagnosed the patient with brain abscess secondary to a bone fracture, and proposed surgery as the only possible treatment. The patient did not consent to surgery. Symptoms worsened, and the patient developed right hemiplegia. A.F. died in June 1883, fifteen months after the accident.

Observation no. 27

M.P., aged 19 years, was hit by a trolley on 21 July 1886, causing an injury to the left frontal region, more specifically the posterior third of the middle and inferior frontal gyri. He initially experienced a concussion, which was followed by a stuporous condition that gradually progressed to coma. The patient's skull was trepanned tangentially to the bone fracture. M.P. progressively recovered consciousness after the procedure. Once his wounds had healed, the miner returned to normal life.

Observation in Appendix A

In 1876, S.G., a 39-year-old man, fired a rifle and was hit above the right eyebrow by the bolt, a few centimetres from the supraorbital ridge. The wound was dressed but the physicians decided not to surgically treat the fracture, which had depressed the frontal bone. The patient was conscious at all times. Ten days after the accident, the miner experienced severe fever; continuous, furious delirium; and violent seizures. He received treatment but, once again, doctors did not surgically remove the bone fragment that was probably responsible for the symptoms. Areilza visited the patient in November 1886, ten years after the accident. During that period, S.G. had continued to experience seizures of varying frequency and intensity, accompanied by a considerable decrease in reasoning ability and memory, and marked behavioural changes (irritability and aggressiveness). He underwent surgery on 17 November and was discharged 18 days later. Trepanation considerably decreased the frequency, duration, and intensity of seizures.

In the second part of the monograph, and for the first and only time, Areilza uses the term "prefrontal lobe" to refer to the superior, middle, and inferior frontal gyri. He explains that despite the limited knowledge about the function of the prefrontal lobe, the literature reported an association between the area and higher brain functions, and suggests that only bilateral and symmetrical lesions can alter said functions.

Areilza concludes that the cases observed in Montes de Triano do not help determine the functional role of this brain region and, at the same time, seem to refute the doctrine of localisation.

El delirio en las fracturas de la base del cráneo (1899)

Areilza published "El delirio en las fracturas de la base del cráneo" (Delirium in patients with basilar skull fractures) in the journal *Revista de Ciencias Médicas de Barcelona* to shed light on the problem of the localisation of higher brain functions.⁶ As in *De las fracturas del cráneo y de la trepanación*, Areilza describes several patients with lesions to different brain regions, and again speculates about the functional role of the frontal lobe.

This time, however, he goes as far as to "experiment" with one of the patients, given the remarkable characteristics of the case.

On 8 February 1898, L.R., a 29-year-old miner, was hit on the forehead by an ore fragment following the blasting of a drill hole. Despite this dramatic accident, L.R. did not lose consciousness and went to the hospital, located three kilometres away, on foot. He requested the wound to be dressed so that he may go home. The doctor who treated L.R. did not discharge him due to the severity of his lesions.

The patient underwent surgery and multiple bone fragments were removed. Through the wound, the physicians could see the frontal lobes, separated by the longitudinal fissure, and the exposed orbital gyri. After surgery, the patient showed no cognitive alterations.

In view of the peculiarity of the case, Areilza conducted an in vivo experiment, mechanically compressing the orbital gyri to determine whether this region was responsible for intellectual ability. On 15 February 1898, Areilza inserted two thin, 6-cm rods through the opening of the fracture, immediately below the right and left orbital gyri. The intervention had no effect: the patient felt no discomfort either in his head or in the wound.

On 17 February, Areilza removed the two rods and placed two thicker ones. Again, no changes were seen. Areilza repeated the procedure on two additional occasions (19 and 21 February), using thicker rods, but no significant changes were observed in the patient's state.

On 23 February, the patients occupying the neighbouring beds reported that L.R. was agitated at night and spoke aloud about his personal affairs while asleep. While awake, however, no alterations were observed in the patient's mental state. Areilza inserted four thick rods into the patient's skull, two under each frontal lobe. The following day, at around two o'clock in the afternoon, L.R. had an epileptic seizure; he lost consciousness, displaying jerking movements in all four limbs. In view of these manifestations, Areilza decided to end the experiment, removing the rods on 26 February. L.R. did not experience any further episodes of seizures.

Areilza concluded that no relevant psychological alterations were observed after systematically and simultaneously compressing both orbitofrontal regions. This led him to rule out an association between these brain structures and an individual's intellectual and moral personality.

Areilza's reasons for conducting the experiment may be linked to the 19th-century interest in studying the pathophysiology of brain compression. The British surgeon Sir Astley Cooper (1768-1841) was a pioneer in this field. In the 1820s, the researcher studied the effect of solid materials on animal brains.⁷ He removed a fragment of skull from a dog in order to compress the dura mater with his fingers. No changes were observed at first. When he pressed harder, however, the animal showed signs of pain and lost consciousness. The German surgeon Friedrich Pagenstecher, from Heidelberg, was the first to systematically study the effects of the presence of a solid mass (wax) in the cranial vault.⁸ In his book *Experimente und Studien über Gehirndruck*, published in 1871, he describes how injecting wax into the cranial vault results in mild neurological symptoms when the mass occupies 0.03% to 0.17% of intracranial capacity, whereas the injection of masses occupying 2.9% to 6.5% results in death.

Conclusion

Today, there is extensive evidence of the association between lesions to the prefrontal circuits and cognitive and behavioural alterations. In the late 19th century, however, this was not the case. In the 1880s, Starr^{9,10} conducted an extensive review of the North American scientific literature and concluded that lesions to the frontal lobe are frequently associated with alterations in cognition, behaviour, and personality. In 1888, Jastrowitz described the case of Panjas, a 38-year-old man who manifested disproportionate euphoria upon admission to hospital. Autopsy revealed a large tumour in the frontal region. Jastrowitz suggested the term "moria" to refer to his patient's behavioural alterations, which were secondary to frontal lobe dysfunction.¹¹ The researcher subsequently described the cases of 12 patients with moria, concluding that this type of behaviour is not observed exclusively in patients with frontal lobe tumours, but also in those with other types of alterations affecting this brain region.

Areilza's observations in the Miners' Hospital of Triano constitute one of the first clinical contributions to the functional study of the frontal lobe. Unfortunately, as occurs with most studies not published in English, his contributions are not well known and are infrequently cited.

Conflicts of interest

The authors have no conflicts of interest to declare.

References

- 1. Pérez Goikoetxea E. Minería del hierro en los montes de Triano y Galdames. Bilbao (ES): Instituto de Estudios Territoriales de Bizkaia; 2003.
- 2. Vitoria Ortiz M. Los hospitales mineros de Triano. Bilbao (ES): La Gran Enciclopedia Vasca; 1978.
- Montalbán J. El doctor Areilza, médico de los mineros. Bilbao (ES): Muelle de Uribitarte Editores; 2008.
- 4. Izquierdo JM. Historia de la neurocirugía española (1950). Neurocirugía. 1993;4:164-71.
- 5. Areilza E. De las fracturas del cráneo y de la trepanación. Barcelona: Tipografía "La Academia" de la Viuda e Hijos de

Evaristo Ullastre; 1887.

- Areilza E. El delirio en las fracturas de la base del cráneo. Revista de Ciencias Médicas de Barcelona. 1899;8:292-307.
- Cooper A. The principles and practice of surgery. London: E. Cox; 1836.
- 8. Pagenstecher F. Experimente und Studien über Gehirndruck. Heidelberg (DE): C. Winters; 1871.
- 9. Starr MA. Cortical lesions of the brain. A collection and an

analysis of the American cases of localized cerebral disease. Am J Med Sci. 1884;87:366-91.

- Starr MA. Cortical lesions of the brain. A collection and an analysis of the American cases of localized cerebral disease. Am J Med Sci. 1884;88:114-41.
- 11. Erickson JM, Quinn DK, Shorter E. Moria revisited: translation of Moritz Jastrowitz's description of pathologic giddiness. J Neuropsychiatry Clin Neurosci. 2016;28:74-6.