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ORIGINAL RESEARCH

Noninferiority assessment of the "neonatal resuscitation and adaptation score" versus the Apgar score.

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Received: July 2, 2021.
Accepted: November 19, 2021
Published: December 8, 2021
Editor: Dr. Paul Astudillo Neira.

Bibliographic letterhead:

Chamorro E, Posso D, Agama F, Espinoza de los Monteros R. Non-inferiority assessment of the "neonatal resuscitation and adaptation score" versus the Apgar score. Revista Ecuatoriana de Pediatría 2021;22(3):Article 20:1-8 doi: https://doi.org/10.52011/109

Abstract

Introduction: Evaluation of the transition from the intrauterine environment in newborns is carried out with the Apgar score (1953), which provides a quick estimation of the clinical state; however, it contains subjective variables in its qualification. The new Neonatal Resuscitation and Adaptation score incorporates neonatal resuscitation interventions. The objective was to demonstrate the noninferiority of the new score compared to the Apgar score.

Methods: An observational, descriptive, cross-sectional study was carried out that used the two scores simultaneously. With a sample of 396 neonates. The univariate analysis used absolute and relative frequencies, and the bivarial analysis used ROC curves for diagnostic accuracy and statistical significance tests.

Results: The need for resuscitation was 35.6%, mechanical ventilation was 19.6%, and the diagnosis of asphyxia was 22%. The ROC curve that examined the variable asphyxia showed a Youden index in favor of the new score in the first and fifth minutes, with similar results in the variables mechanical ventilation and neonatal resuscitation.

Conclusion: The neonatal resuscitation and adaptation scores were not lower than the Apgar score in the assessment of asphyxia. Like its predecessor, it recognizes the need for resuscitation as well as the need for mechanical ventilation in neonates with low scores. It is a new tool with easy application and understanding for the determination of the transition state in newborns.

Keywords:

MESH: Apgar Score; Cardiopulmonary Resuscitation; Asphyxia Neonatorum; Live Birth; Infant, Newborn; Adaptation.

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Introduction

Birth is a critical period; therefore, countless investigations have focused on perinatal conditions and ways to evaluate it, such as the Neonatal Resuscitation Program that was developed by the American Heart Association and the American Academy of Pediatrics [1], the ACoRN strategy, initial care for neonates at risk [2], developed by the ACoRN Neonatological Society of Canada or the STABLE program for post-resuscitation and pre-transport care for ill neonates [3]. The oldest score, Apgar, has been more than 60 years since Virginia Apgar published it; it is used universally to this day for its speed and ease of performance. It comprises 5 components in its evaluation: color, heart rate, reflexes, muscle tone and respiration. Each of these components is assigned a score of 0, 1, or 2 [4]. Quantify clinical signs of neonatal depression, such as cyanosis or paleness, bradycardia, depressive response to stimulation, hypotonia, and apnea or gasping. It is reported at the first minute and 5 minutes after birth for all infants and at 5-minute intervals thereafter until 20 minutes for infants with a score less than 7 [4]. Of the signs previously listed, Dr. Apgar herself indicated in her original work that color was the least satisfactory sign to evaluate due to the large difference between observers. Other signs that can be considered controversial in their qualification are reflexes and muscle tone, since the latter, for example, can vary significantly depending on gestational age [4].

According to the American Academy of Pediatrics [1] the Apgar score is a convenient method of informing the newborn's status after birth and the response to resuscitation. In the Neonatal Encephalopathy and Neurological Outcome report [5] an Apgar score of 0 to 3 at 5 minutes was considered a nonspecific sign of disease; however, a persistently low score by itself is not a specific indicator of intrapartum compromise. Although the score is widely used in studies, its inappropriate use has led to an erroneous definition of birth asphyxia.

Perinatal asphyxia is considered a lack of blood flow or gas exchange to or from the fetus in the period immediately before, during or after the birth process, and it can lead to profound systemic and neurological sequelae due to decreased blood flow and/or oxygen to a fetus or baby during the peripartum period [6].

The diagnostic criteria for neonatal hypoxic-ischemic encephalopathy are as follows: metabolic acidosis with pH <7.0 (in umbilical cord or infant blood sample), base deficit -12, APGAR score = five at 10 minutes with a continued need for resuscitation, presence of multiple organ-system failures, clinical evidence of encephalopathy: hypotonia, abnormal oculomotor or pupillary movements, weak or absent suck, apnea, hyperpnea, or clinical seizures, and neurologic findings that cannot be attributed to other causes (inborn error of metabolism, a genetic disorder, congenital neurologic disorder, medication effect) [6].

It is important to recognize the limitations of the Apgar score. Its evaluation is the expression of the physiological condition of the baby at a point in time, which includes subjective components, and there are numerous factors that can influence the score, including sedation or maternal anesthesia, congenital malformations, gestational age, trauma, and interobserver variability [1].

Furthermore, biochemical alterations must be significant before the score is affected. The score can also be affected by variations in the normal transition. For example, lower initial oxygen saturations in the first few minutes do not require immediate supplemental oxygen delivery [1].

The incidence of low Apgar scores is inversely related to birth weight, and a low score cannot predict the morbidity or mortality of any individual infant [1]. A change in the score between the first and fifth minute is a useful index of the response to resuscitation; if it is less than 7 at 5 minutes, the Neonatal Resuscitation Program guidelines well that the evaluation should be repeated every 5 minutes for up to serve 20 minutes [7].

However, an Apgar score assigned during resuscitation is not equivalent to a score assigned to a spontaneously breathing infant. There is no accepted standard for reporting an Apgar score in infants resuscitated after birth because many of the items that are scored are altered by resuscitation.

From the above, it is concluded that it is necessary to concatenate the knowledge acquired over the years. Therefore, in 2015 Jurdi and Cols. [8], published the evaluation of a neonatal resuscitation scale called the Neonatal Resuscitation and Adaptation Score (NRAS) (Table 1), comparing it with the Apgar score, in which the concepts of neonatal resuscitation were included.

The new score evaluates 5 parameters comparable to its predecessor: cardiovascular component, with two elements, heart rate and cardiac compressions; neurological component with reflex response; and, finally, a respiratory component related to the supplemental oxygen requirement; each element is capable of measurement and verification [8].

In the NRAS, resuscitation actions also receive ten points and are recorded in minutes 1 and 5. Similar to the Apgar score, each element is scored with 0, 1 and 2. Inclusion in the new method of elements of the program neonatal resuscitation, especially for the respiratory component, is where its novelty lies and its ability to improve the usefulness at the time of reporting on the need for mechanical ventilation of the resuscitated neonate [8].

The results obtained in the NRAS study tipped the balance in favor of the new evaluation method, since it was superior in relation to the prediction of mortality and the need for ventilatory support at 48 hours [8, 9]. Furthermore, the strong correlation between the two scores (r> 0.80 at 1 and 5 min) implies that the ability of NRAS to assess the infant's status during resuscitation is similar to that of the Apgar score [9].

There were small differences that are significant between the two systems and that in the results show the real differences in what each one measures: while the Apgar focuses on the baby's condition, the NRAS is more focused on the needs and responses to resuscitation of the same. In addition, NRAS was superior in predicting mortality, as it reduced the number of false positive scores. An NRAS <7 had higher positive predictive values than a similar Apgar score for the need for ventilation at 48 hours of life [9].

A system such as the NRAS could be useful to identify newborns who deserve subsequent resuscitation, beyond the current recommendations of the neonatal resuscitation program, which would allow us to obtain better long-term results in the treatment of babies requiring supplemental oxygen or positive pressure ventilation at the time of delivery [9]. Therefore, the aim of the present study was to demonstrate the noninferiority of the new score compared to the Apgar score in a Hispanic population in Ecuador.

Population and methods

Design of the investigation

This is an observational cross-sectional study.

Stage

The study was carried out in the neonatology area of the Enrique Garcés Hospital of the Ministry of Public Health, Quito, Ecuador. The study period was from January 1, 2018, to December 31, 2019. The report was completed on July 30, 2020.

Inclusion criteria

Newborn patients from week 23 of gestation onwards entered the study. Patients transferred to another health home, newborns born at home and newborns arriving at the institution after birth (hours or days) were excluded. The elimination criteria were cases with incomplete or inconsistent records.

Study size

The sample calculation was probabilistic and of a simple random type. The determination of the sample size was made based on the calculation to estimate a proportion [10], with a 95% confidence interval and 5% error, and the sample size was 347 cases.

Table 1 Neonatal Resuscitation and Adaptation Score (NRAS)

Item/Score	0	1	2
Heart rate (C1)	Absent	< 100 bpm	> 100 bpm
Cardiovascular support (C2)	No response to chest compressions	Heart rate improves to> 60 bpm with chest compressions	No additional cardiovascular support
Reflex response (N1)	No Grasping reflex	Incomplete Grasping reflex (partial finger flexion)	Full Grasping reflex (full finger flexion)
Supplemental oxygen (R1)	> 40%	< 40%	Room air (21%)
Respiratory Support (R2)	Respiraciones con presión positiva sin esfuerzo respiratorio espontáneo	Positive pressure breaths without spontaneous respiratory effort CPAP or positive pressure ventilation with irregular spontaneous respiratory effort	No additional respiratory support

bpm: beats per minute

Variables

The variables were gestational age, sex, need for neonatal resuscitation, Apgar test, and NRAS score (see Table 1).

Data / Measurement Sources

The data were collected from the normal activities of the neonatology service. This research work did not involve any additional procedure to the one that is routinely provided in the initial care of newborns in any public or private health home nationwide in Ecuador and has no experimental action on the study subjects, so this study did not imply any short, medium or long risks for newborns. The data were compiled in an electronic spreadsheet to later be transferred to the statistical software.

Statistical method

Descriptive statistics are used through tables, which represent the absolute and relative frequencies of the qualitative variables. Diagnostic test analysis using ROC curves is used.

Results

The study included 396 newborns: 74.48% at term, 24.5% preterm, and 2.02% postterm. They were 55.8% men and 44.2% women.

According to the Apgar score at the 1st minute, 7.07% had severe depression, and 13.63% had moderate depression. Apgar at the 5th minute, 0.5% had severe depression, and 6.31% had moderate depression. With the NRAS at the 1st minute, 5.30% had a minute severe depression and 20.45% had moderate depression, 20.45%. NRAS at the 5th minute showed that 0.5% had severe depression and 8.58% had moderate depression.

35.6% of the newborns required neonatal resuscitation. Neonates diagnosed with asphyxia were 22%. A total of 19.7% of the newborns required mechanical ventilation.

Diagnostic tests

For the neonatal asphyxia variable, using the 1st minute Apgar and NRAS scores, the area under the curve was 0.935 for Apgar and 0.968 for NRAS.

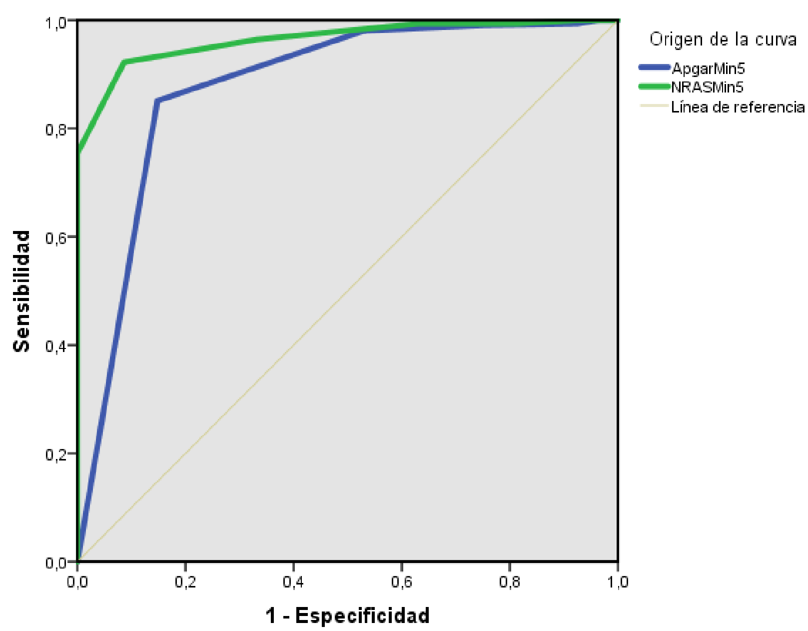

Fig. 1 ROC curve: Apgar vs. NRAS in Birth Asphyxia at 1st minute. Figure 1 shows the ROC curve that compares the Apgar score and NRAS at minute 5, evaluating the variable asphyxia. The two tests have very important areas under the curve with values very close to unity, with 0.878 and 0.964 for Apgar and NRAS respectively, however, the NRAS score is higher with a higher Youden index and a difference of 0.086, statistically significant (P <0.001).

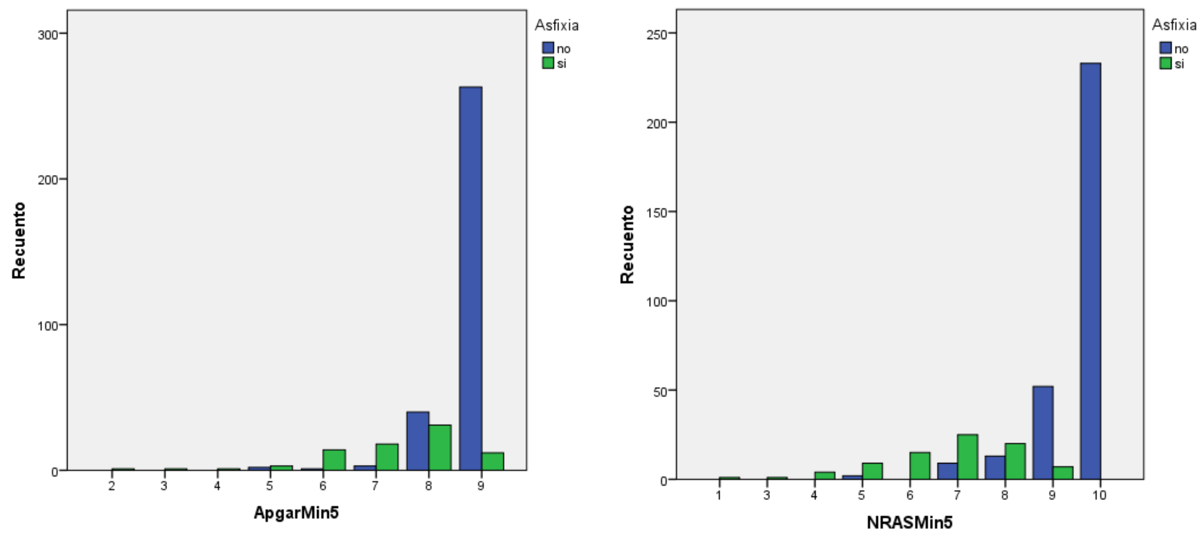

Fig. 2 Neonatal asphyxia measured with the Apgar test (left) and NRAS (right) at minute 5. Figure 2 shows in bars, the distribution of the frequencies of those neonates in whom asphyxia was diagnosed in relation to the Apgar score qualification.

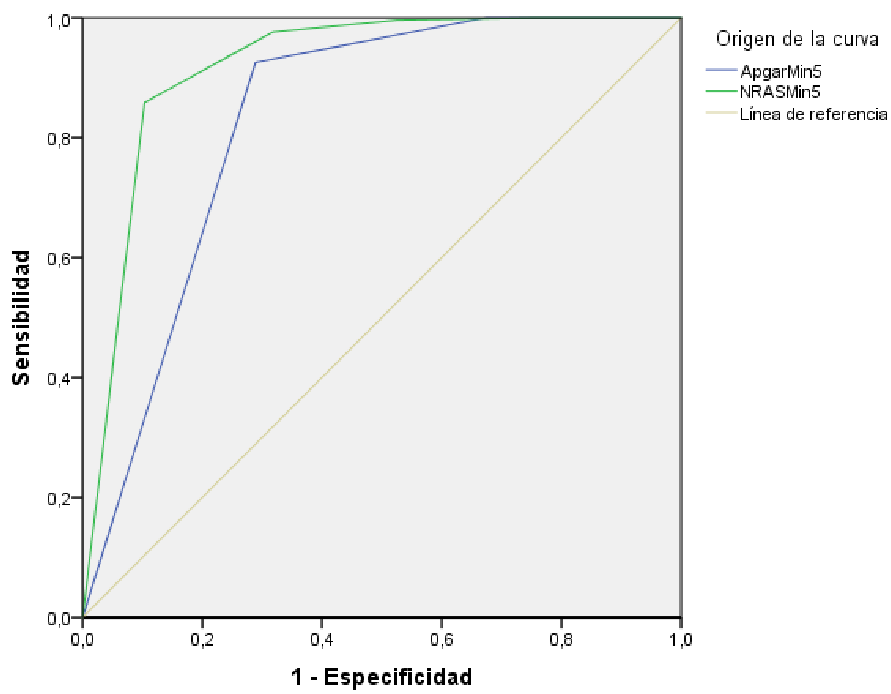

Fig. 3 ROC Apgar curve vs. NRAS in Neonatal Resuscitation at minute 5. The graph shows the ROC curve in which the Apgar score and NRAS at minute 5 are compared, evaluating the neonatal resuscitation variable. The two tests have very important areas under the curve, with values indicating 0.830 for Apgar and 0.920 for NRAS, with a difference of 0.09 in favor of the second test, with a clearly higher Youden index.

At the 5th minute, the area under the curve was 0.878 for the Apgar scale and 0.964 for NRAS (Figure 1). The NRAS score is higher than the Apgar score because it presents a higher Youden index, and a similar pattern is repeated when an extra comparison was made at minute 10. The Apgar score underestimates the clinical status score, giving higher scores to patients in whom the diagnosis of asphyxia is subsequently confirmed, while NRAS is more accurate in the classification, as can be observed in the comparison between the bars in Figure 2.

For the neonatal resuscitation variable at the 1st minute, the area under the curve for the Apgar test was 0.91, and for NRAS, it was 0.989. At the 5th minute, the area under the curve for the Apgar test was 0.83, and for NRAS, it was 0.92 (Figure 3).

For the variable mechanical ventilation at the 1st minute, the area under the curve of the Apgar test was 0.85 and that of the NRAS was 0.78. At the 5th minute, the area under the curve for the Apgar test was 0.74, and for NRAS, it was 0.89 (Figure 4).). In an extra assessment at minute 10, values of 0.676 vs. 0.780 for Apgar and NRAS, respectively, in this last comparison, Apgar lost statistical significance, while NRAS maintained its superiority with statistical significance at *P*= 0.004.

Sensitivity and specificity of NRAS

For the variable "neonatal asphyxia", a high specificity and a high negative predictive value were obtained. For the variable "neonatal resuscitation", a high specificity, a low sensitivity and a high positive predictive value were obtained. Finally, in the variable "mechanical ventilation", a very good specificity and a good negative predictive value were obtained (Table 2).

Table 2 NRAS diagnostic tests

	S	E	PPV	NPV
Birth Asphyxia	0.75	0.94	0.80	0.93
Neonatal resuscitation	0.54	0.98	0.93	0.79
Mechanic ventilation	0.52	0.87	0.5	0.88

S: Sensitivity, E: specificity, PPV: positive predictive value, NPV: negative predictive value.

Discussion

The sample was calculated in 347 newborns; however, due to the number of births and the ease of obtaining the data, it was possible to evaluate 396 newborns with the two scores performed simultaneously, with the

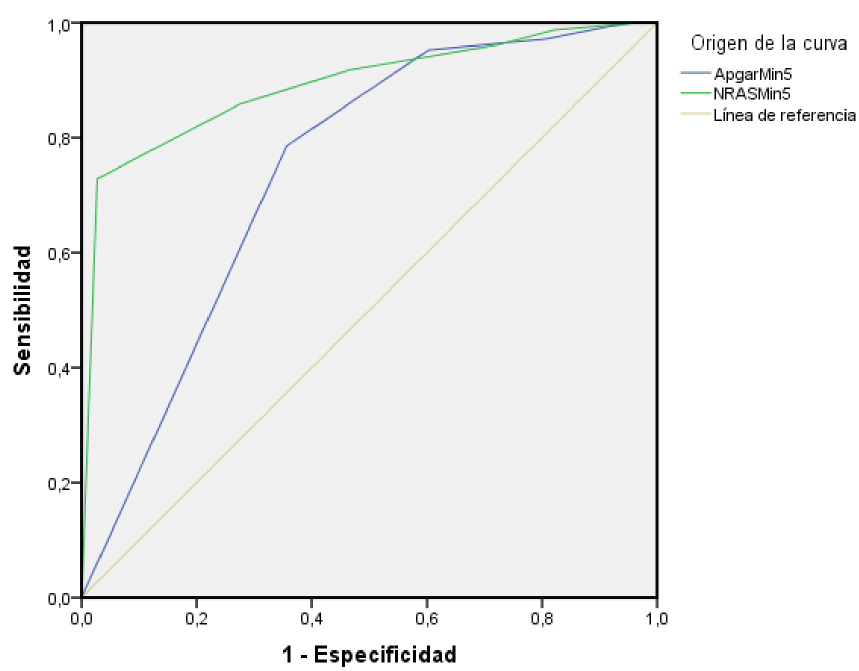

Fig. 4 ROC curve: Apgar vs. NRAS in mechanical ventilation at minute 5. The graph shows the ROC curve in which the Apgar score and NRAS at minute 5 are compared, evaluating mechanical ventilation. The two tests have significant areas under the curve, whose values correspond to 0.742 and 0.89 for Apgar and NRAS respectively, after comparison, the NRAS score is higher with a higher Youden index, and a difference between scores of 0.149.

qualification in all cases, so all data were included for analysis, without losses.

The percentage distribution of sex corresponded to a predominance of sex, at a ratio of 1.2:1 males in relation to females.

When the Apgar and NRAS tests were scored at the first and fifth minutes, similar fluctuations were evidenced in terms of the estimated classification.

Regarding asphyxia, 22% of newborns confirmed this diagnosis with blood gas determination. Male babies were the ones who most frequently presented this diagnosis, as they represented 63.2% of all cases. According to international reports, the asphyxia rate is 1 per thousand live births [11], In the present study, 6 per thousand live births were reported; likewise, when evaluating the need for neonatal resuscitation, the international reference was 10% [7, 12, 13], and in the present study, 35.6% was reported. These differences are because the center in which the study was carried out is a second-level unit to which cases refer that cannot be resolved at the first level of care.

In hospital follow-up, approximately 20% of neonates required mechanical ventilation, which contrasts with a regional study carried out in Havana in which 7% of those admitted received this therapy [14].

The areas under the ROC curves showed superiority of the NRAS over the Apgar test in all the main comparisons, whether for asphyxia, neonatal resuscitation or mechanical ventilation, statistical significance was maintained even in evaluations at 10 minutes.

Within the sensitivity and specificity analysis, the Apgar score was taken as the gold standard. Regarding the variable asphyxia, NRAS has significant values that would help in an early evaluation of asphyxia, as it is one of the main causes of mortality in newborns [11]. For the neonatal resuscitation variable, the sensitivity value was not satisfactory, but the rest of the results were useful. For the mechanical ventilation variable, the results reduce the usefulness of this test in terms of determining the need for it.

A multicenter study at the national level is necessary to confirm and strengthen the evidence found in this research work, with amplification in the clinical variables of the study, with the aim of improving the specific application of NRAS.

Conclusions

The present study shows that the Neonatal Resuscitation and Adaptation Score is not inferior to the Apgar score for the diagnosis of asphyxia. It was possible to define that the NRAS score has a high sensitivity and specificity for the assessment of asphyxia that could influence the long-term neurological prognosis in newborns. By confirming that the NRAS test is not lower than Apgar, it could replace the latter in the initial evaluation of the newborn. This new test provides an easy-to-apply and understandable tool for determining the transition state in newborns.

Abbreviations

NRAS: Neonatal Resuscitation and Adaptation Score - NRAS. PICU: Pediatric Intensive Care Unit.

Supplementary information

Supplementary materials are not declared.

Acknowledgments

We acknowledge and thank the Enrique Garcés Hospital authorities who facilitated the study.

Authors' contributions

Emilia Chamorro Villota: Conceptualization, Data preservation, Fund acquisition, Research, Resources, Software, Writing - original draft, Writing: review and editing.
Diana Posso Pasquel: Conceptualization, Data Conservation, Fund Acquisition, Research, Resources.
Fernando Agama Cuenca: Data curation, research, acquisition of funds.
Rommel Espinoza De Los Monteros: Methodology, Formal Analysis, Project Administration, Supervision, Validation, Visualization.

Financing

The authors financed the expenses incurred in the production of this research.

Availability of data and materials

The data sets generated and/or analyzed during the current study are not publicly available due to the confidentiality of the participants but are available through the corresponding author upon reasonable academic request.

Declarations

Ethics committee approval and consent to participate

This work has the approval of the Research Ethics Committee of Enrique Garcés Hospital.

Publication consent

It does not apply to studies that do not publish MRI/CT/Rx images or physical examination photographs.

Conflicts of interest

The authors declare no conflicts of interest.

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