

Semiology of the neurocritical patient: understanding the language of neurological signs

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Abstract

A fundamental aspect of caring for neurocritical patients is interpreting and understanding their neurological signs and symptoms. This will be a helpful key to determining the brain injury or dysfunction's location, extent, and severity. The semiotics of the neurocritical patient encompasses various domains, including motor, sensory, cognitive, and autonomic functions. A comprehensive understanding of the semiotics of the neurocritical patient empowers clinicians to make timely and accurate diagnoses, predict outcomes, and implement targeted therapeutic interventions. It also enables effective communication among the interdisciplinary team members involved in the patient's care. This article review shows the importance of accurately recognizing and deciphering these signs to guide clinical decision-making.

Keywords: Semiology. Neurocritical care. Neurological signs. Diagnostic tools. Neurological examination.

Semiología del paciente neurocrítico: comprensión del lenguaje de signos neurológicos

Resumen

Un aspecto fundamental en el cuidado del paciente neurocrítico es la interpretación y comprensión de sus signos y síntomas neurológicos. Esta será una clave útil para determinar la ubicación, el alcance y la gravedad de la lesión o disfunción cerebral. La semiótica del paciente neurocrítico abarca varios dominios, incluyendo funciones motoras, sensoriales, cognitivas y autonómicas. Una comprensión integral de la semiótica del paciente neurocrítico permite a los médicos realizar diagnósticos oportunos y precisos, predecir resultados e implementar intervenciones terapéuticas específicas. También permite una comunicación efectiva entre los miembros del equipo interdisciplinario involucrado en el cuidado del paciente. La revisión de este artículo muestra la importancia de reconocer y descifrar con precisión estos signos para orientar la toma de decisiones clínicas.

Palabras claves: Semiología. Cuidados neurocríticos. Signos neurológicos. Herramientas diagnósticas. Exploración neurológica.

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Introduction

The neurological patient usually confuses the examiner because of the complexity of the nervous system (central and peripheral). They are typically patients who are suffering from severe and sometimes fatal diseases. The intensive care unit (ICU) is no exception for this type of situation since this is where the most complex patients of the entire hospital are, in most cases, fighting daily against death, either because of the neurological disease itself or because of the multiple systemic complications.

This article review aims at medical students, generalist physicians, residents, and specialists in neurological sciences. It aims at the initial approach of all patients with neurological pathology so that, over and over, the neurological examination is more orderly, systematic, and logical to provide the patient with a proper approach, prompt diagnosis, and rapid establishment of medical and sometimes surgical treatment¹.

In the following pages, you will find in a very summarized and concise way the evaluation of the main aspects to take into account for the assessment of the neurological patient. In addition, we propose a decision-making algorithm based on current evidence so the reader can have a guide when assessing a neurocritical patient, reducing the risk of error in diagnosis and treatment (Fig. 1).

Neurocritical anamnesis: unveiling unknown territory

The performance of an adequate anamnesis is paramount to ensure precise diagnosis and effective treatment. This is a formidable task in critical illness and especially taxing when patients are confused, aphasic, or, worse, sedated, and intubated. Gathering all relevant information about the patient's medical background, including past illnesses, surgeries, medications, and allergies, is essential (ideally, given by close family members), but these often must travel separately, arriving significantly after the patient. This information enables health-care providers to make informed decisions and provide the best possible care to their patients since it allows for a subjective vision of the nosological entity that affects the person and objectively with directed questions can be routed and understanding the natural history of the most frequent diseases of daily medical practice. It is crucial to consider fundamental factors such as sex, age, and gender. Since they make the person more or less at risk of presenting a specific pathology or make one diagnosis more probable than another. We can expect to miss

important points; they accumulate quickly in the heat of the moment^{2,3}.

In the intensive care setting, most of the time, the clinical condition of the patient makes it impossible to obtain as detailed anamnesis as desired, which is why family members are a fundamental part of this first step of the clinical history since they are the ones who will provide the most data on the onset of symptoms, whether these were sudden or gradual, associated with particular clinical situations (weight loss, behavioral or behavioral changes, fever, seizures, sensory or motor disturbances, and among others)⁴. When obtaining medical history, gathering comprehensive details regarding any prior medical conditions, the treatments received, and the approach taken to manage them is crucial. This information can provide valuable insights into a patient's health status and guide healthcare professionals in making informed decisions regarding their care (Arterial hypertension, diabetes mellitus, hormonal disorders, etc.) With this knowledge, any clinical changes or emerging symptoms can be explained and addressed more effectively⁵.

Ensuring patient safety is an essential aspect of healthcare, and one of the critical measures to take is to check for any allergies the patient may have. This step is high-priority as it helps any adverse reactions or negative outcomes that may arise from exposure. It is crucial to confirm or rule out the consumption of substances of abuse, such as drugs or alcohol, since it is not uncommon for these to affect the mechanism of action of drugs frequently used in the ICU or, more regularly, for patients with drug dependence to require higher doses than usual or shorter intervals between doses. Another essential aspect of being considered is exposure to pollutants or substances with carcinogenic potential (wood smoke, tobacco, heavy metals, pesticides, etc.) since they can be fundamental in understanding lesions that are identified as imaging studies are evaluated⁵.

At the end of the anamnesis, a review by systems should be done to evaluate aspects that currently afflict the patient since, in some situations, the reason for the current consultation is not the same as at the beginning of the symptomatology or has been accompanied by other alterations that are important to highlight in the history. Aspects such as pain, weight loss, associated symptoms such as fever or cough, gastrointestinal problems, or changes in skin color can help the evaluating physician to identify aspects that give greater weight to define the diagnosis of a patient or that, on the contrary, suggest non-neurological clinical entities that may have repercussions in the nervous system⁶.

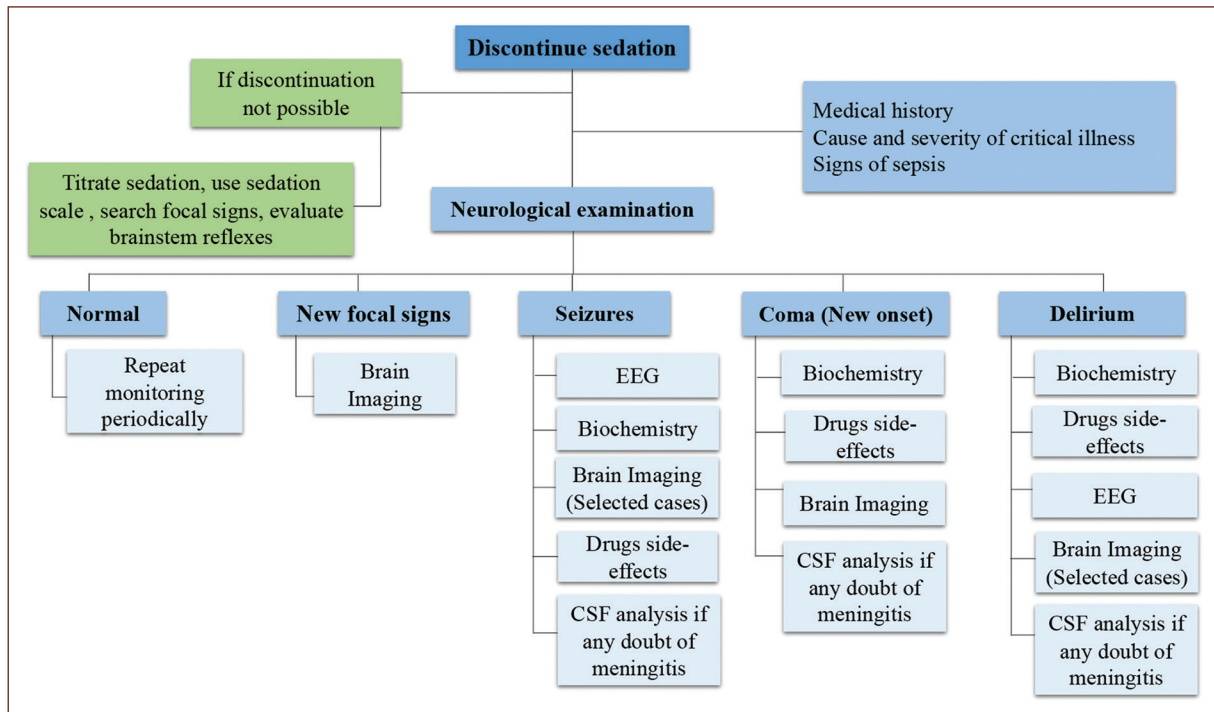


Figure 1. Algorithm diagnostic approach to acute brain dysfunction in intensive care unit.

Neurocritical exploration: unmask neurological signs through physical examination

An adequate evaluation of the physical examination of the neurological and neurocritical patient is the cornerstone to understanding the current pathology on many occasions or why the association with other findings in different systems or organs. In the neurocritical patient, it is the tool that takes on greater weight for the physician since due to the patient's acute and severe condition of the patients, it is not possible to make a structured and complete interview of the patient. It is for this reason that the reader (student, general practitioner, or resident) should gradually become familiar with the clinical manifestations of different nosological entities and create an algorithm of approach according to the objective findings that are obtained, thus in case of being front of a similar patient will be more familiar and therefore, the fear or distrust in their knowledge will be less and therefore be able to provide better care to their patients. It is not surprising that neurocritical patient is not to the liking of all health personnel since, in many cases, they are patients with behavioral and behavioral alterations that make them difficult to treat, either because they are aggressive or because they do not want to respond to questioning

or collaborate in the physical evaluation, which makes the student initially avoid this type of patient^{7,8}.

The physical examination has several parts that should ideally be evaluated, organized, and systematically. Still, it should be noted that it is not always possible to do it in the same order or the same number of maneuvers, which is why the examiner must create increasingly dynamic strategies in the evaluation and interpretation of clinical signs that help to guide the most likely diagnosis, which in many cases will be confirmed by both imaging and paraclinical studies (Fig. 2).

It is vital to identify findings that may suggest intra lesions on physical examination, such as retroauricular ecchymosis (Battle's sign) or palpebral ecchymosis (raccoon eyes) that may occur in patients with skull base fractures. It is possible to identify tongue lesions in individuals who experience epileptic seizures¹.

To ensure a more objective neurological evaluation, it is important to recognize the initial stabilization of the patient. This begins with assessing the airway as the first step; it is essential to identify which patient requires securing the airway with invasive devices to avoid cerebral hypoxia, aspiration of secretions, and thus secondary pulmonary infectious processes⁶. Among the different aspects to evaluate which patient requires

intubation are the Glasgow coma scale (GCS) (Table 1)⁹ and assess which patient's state of consciousness is better to secure the airway and thus avoid more sequelae; as a general rule, all patients with GCS < 9 should have a secured airway. However, it is essential to rule out intoxications that can reduce the state of consciousness and thus decrease the GCS score to avoid intubation in patients who sometimes do not require it (especially in alcoholic intoxication and hypoglycemia). It is also vital to evaluate ventilatory aspects that inform the physician which patient may require assisted ventilation, such as the use of accessory muscles for breathing, foreign objects in the oral or nasal cavity that interfere with the adequate passage of air to the lungs, poor management of secretions or abundant bleeding that may cause bronchoaspiration and thus aspiration pneumonia. Fundamental for an objective assessment of the neurological examination is to maintain a mean arterial pressure between 65 mmHg and 70 mmHg to ensure adequate cerebral and spinal perfusion pressure. In some cases, revitalization with intravenous fluids or vasopressor drugs is necessary to provide these goals^{1,6,9}.

Once the patient is stable or as stable as possible, a directed neurological examination consistent with the patient's clinical status should be performed since completing every aspect of the neurological evaluation is impossible. Ideally, a rapid evaluation of the patient's mental component should be done from the moment the physician approaches the patient; they may notice changes in their behavior or behaviors that already provide information about possible pathologies or even affected encephalic areas. Initially, the patient's consciousness should be evaluated, starting with alertness¹⁰. It is advisable to categorize the patient into one of the following categories:

- Alert: The patient has and keeps his eyes open, can pay attention, and follows orders
- Drowsy: The patient opens his eyes to auditory stimulus and keeps them open for over 10 s. However, if there is no stimulus, the patient closes them again. The patient is able to obey simple commands
- Stuporous: The person opens the eyes to tactile or painful stimulus and cannot keep them open for more than 10 s despite external stimuli. Usually does not obey simple commands
- Comatose: The patient does not open his eyes despite vigorous painful stimuli. It is necessary to secure the airway to avoid the risk of bronchial aspiration or cerebral hypoxia.

The physician needs to detect changes in the state of alertness since several situations can simulate neurological deterioration and not necessarily be caused by

Table 1. Glasgow coma scale: the Glasgow coma scale provides a practical method for assessing impairment and estimating coma severity based on eye, verbal, and motor criteria

Response	Scale	Score
Eye opening response	Eyes open spontaneously	4 points
	Eyes open to verbal command, speech, or shout	3 points
	Eyes open to pain (not applied to face)	2 points
	No eye opening	1 point
Verbal response	Oriented	5 points
	Confused conversation, but able to answer questions	4 points
	Inappropriate responses, words discernible	3 points
	Incomprehensible sounds or speech	2 points
	No verbal response	1 point
Motor response	Obeys commands for movement	6 points
	Purposeful movement to painful stimulus	5 points
	Withdraws from pain	4 points
	Abnormal (spastic) flexion, decorticate posture	3 points
	Extensor (rigid) response, decerebrate posture	2 points
	No motor response	1 point

Minor brain injury: 13–15 points; Moderate brain Injury: 9–12 points; Severe brain injury: 3–8 points.

central pathologies, such as hypoglycemia, alcoholic and non-alcoholic intoxication, hydroelectrolyte disorders (especially dysnatremia), exogenous or endogenous intoxications, alterations in renal function, and among others. For this reason, the physical examination will direct the subsequent medical conduct. However, it is not the objective of this review^{10,11}.

The degree of consciousness of a neurocritical patient can also be assessed objectively with the FOUR scale (Fig. 3)¹², which allows a more precise staging of the degree of response according to four essential parameters (ocular response, motor response, brain stem reflexes, and respiration). It is essential to evaluate the degree of sedation since most neurocritical patients are under the effects of drugs that cause the neurological examination may be modified or may not be able to develop all the

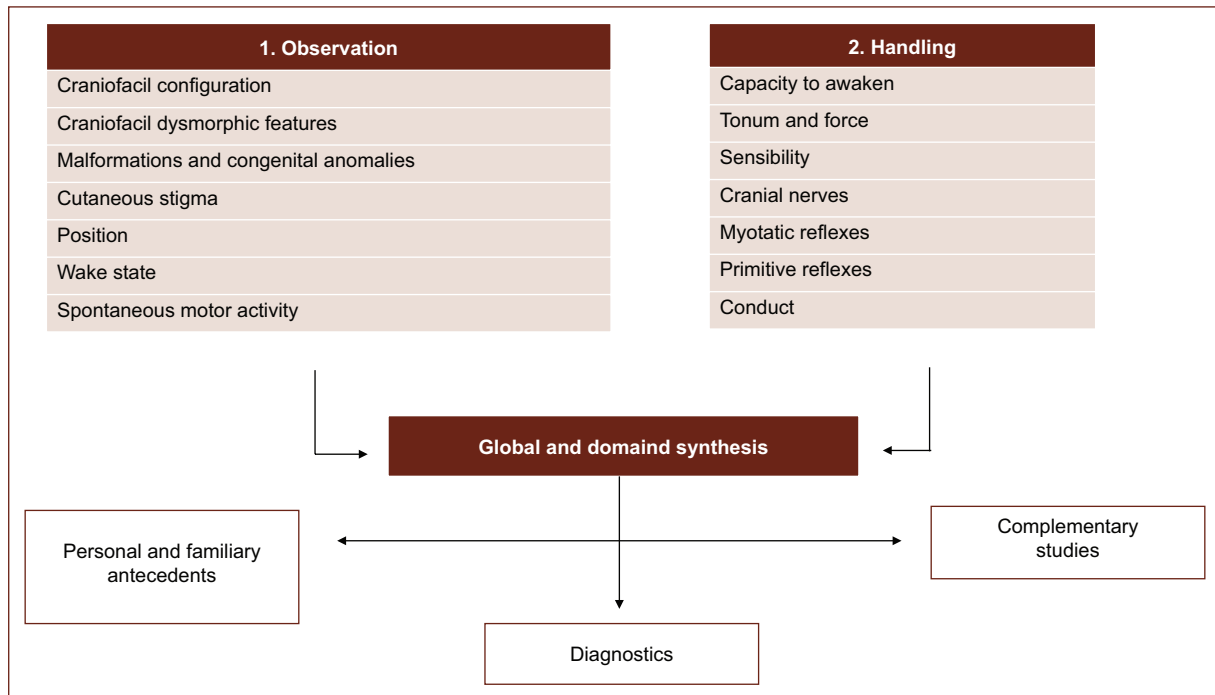


Figure 2. Example dynamic physical examination. Adaptaded from Sharshar et al., 2014.

activities of an adequate neurological examination; the Richmond agitation and sedation scale (Table 2)¹¹. The degree of consciousness of a neurocritical patient can also be assessed objectively with the FOUR scales, which allows a more precise staging of the degree of response according to the four essential parameters¹².

Frequently, there is some degree of disorientation in patients hospitalized in ICUs since, on many occasions, the lights are kept on day and night, and the circadian cycle is not adequately identified. There are also many internal and external monitoring systems with alarms and light bulbs that turn on and off 24 h a day, and some patients remain alone in the rooms, which increases the risk of disorientation and delirium^{7,8}.

Language assessment is quite complex, and for the neurocritical patient, it is often necessary to be very specific to identify aphasia or dysphasia of a motor, sensorineural, or mixed type (Fig. 4). From the first moment, the physician introduces himself and greets the patient; he is performing the language evaluation since if the patient understands what is being discussed, obeys orders, and emits sounds, it is logical to think there are no significant alterations at this level. It is also important to evaluate the fluency of spoken language and speech coherence as they may be altered in patients with delirium, bipolar disorders (manic phase), and disorganized thinking. The speed of speech

and the number of ideas that are expressed evaluate not only the language but also the speed of thought so that tachylalia and flight of opinions can give a picture of the degree of mental compromise in the patient^{1,2,4}.

Finally, it is essential to clarify that more areas are evaluated in the mental part but that, due to the clinical context of the patient, are not usually evaluated but that should be kept in mind in specific cases, and that may require more elaborate strategies carried out by psychologists or psychiatrists. A fundamental aspect that the reader should not forget is that before thinking or making diagnoses of mental illnesses, all possible organic causes that may lead to cognitive alterations should be ruled out since, many times, the reason is processes that can be medically corrected and thus resolve the clinical change. It is also important to rule out structural lesions before thinking about mental illnesses; that is why neuroimaging should be done to evaluate possible collections, masses, and cerebral edema before the psychiatrist's evaluation¹³.

Neurocritical assessment of motor system: enhancing physical examination

An essential part of the physical examination of the neurocritical patient is the evaluation of strength in the four extremities, which requires the active collaboration

Table 2. The Richmond agitation–sedation scale. The Richmond agitation sedation scale is an instrument designed to assess the level of alertness and agitated behavior in critically ill patients

Score	Term	Description
+4	Combative	Overtly combative or violent, immediate danger to staff
+3	Very agitated	Pulls on or removes tubes or catheters, aggressive behavior toward staff
+2	Agitated	Frequent non-purposeful movement or patient ventilator dyssynchrony
+1	Restless	Anxious or apprehensive but movements not aggressive or vigorous
0	Alert and calm	
–1	Drowsy	Not fully alert, sustained (> 10 s) awakening, eye contact to voice
–2	Light Sedation	Briefly (< 10 s) awakens with eye contact to voice
–3	Moderate sedation	Any movement (but no eye contact) to voice
–4	Deep sedation	No response to voice, any movement to physical stimulation
–5	Unarousable	No response to voice or physical stimulation
Procedure		
1.	Observe patient. Is patient alert and calm (Score 0)?	
2.	Does patient have behavior that is consistent with restlessness or agitation?	
	Assign score+1 to+4 using the criteria listed above.	
3.	If patient is not alert, in a loud speaking voice state patient's name and direct patient to open eyes and look at speaker. Repeat once if necessary. Can prompt patient to continue looking at speaker.	
	Patient has eye opening and eye contact, which is sustained for more than 10 s (Score-1).	
	Patient has eye opening and eye contact, but this is not sustained for 10 s (Score-2).	
	Patient has any movement in response to voice, excluding eye contact (Score-3).	
4.	If patient does not respond to voice, physically stimulate patient by shaking shoulder and then rubbing sternum if the is no response.	
	Patient has any movement to physical stimulation (Score-4).	
	Patient has no response to voice or physical stimulation (Score-5).	

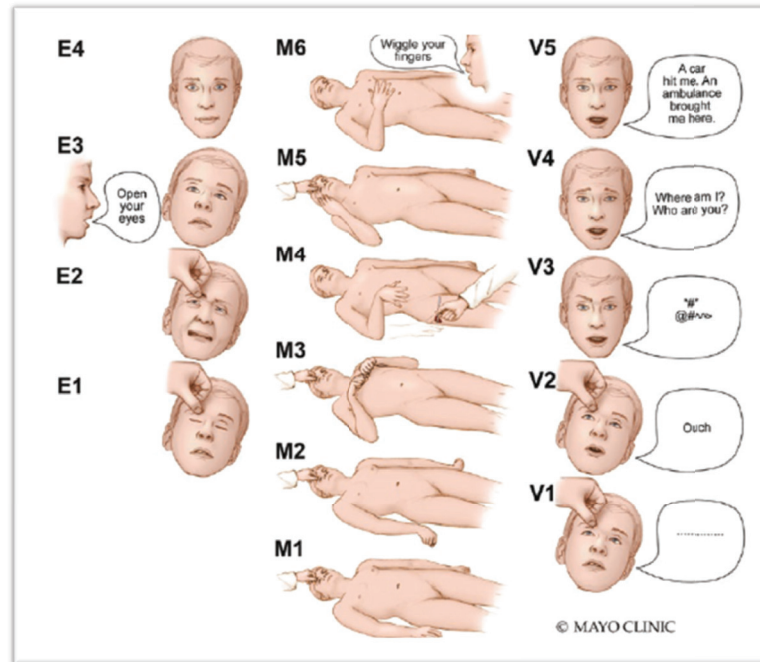
Adapted from Sessler et al. 2002¹¹.

of the patient to be more objective. Usually, the patient does not undergo a gait test in the critical care unit; however, at the time of admission and as long as the clinical condition allows it, special attention should be paid to the gait pattern since it may indicate to the physician alterations of both upper and lower motor neurons. It is vital to identify hemiparetic, tabetic, or ataxic gait, which in many cases may be secondary to contralateral cortical, posterior medullary, or cerebellar alterations, respectively¹⁴.

An easy scale to implement in the ICU is the Daniels scale, which allows us to give a more specific degree of paresis and thus be able to see the evolution of the same and thus define whether there is a neurological deterioration or, on the contrary, improvement at the

motor level. For its proper completion, the patient's collaboration is required, which is why it is not possible to evaluate critically ill patients in many cases. For patients with spinal cord trauma, it is essential to correctly complete the ASIA scale (Table 3)¹⁵ by evaluating all ten muscle groups it assesses. Remember that the higher the lesion, the greater the patient's motor, sensory, or sphincter involvement¹⁴.

The evaluation of reflexes should become a daily activity of the physical examination and not only at the musculotendinous level but also myocutaneous, cremasterine, and bulbocavernosus reflexes, especially in patients in the context of spinal cord trauma since they will differentiate patients with complete spinal cord injury from incomplete and thus change the prognosis



Eye response (E)	Brainstem reflexes (B)
4 = eyelids open, tracking, or blinking to command	4 = pupil and corneal reflexes present
3 = eyelids open but no tracking	3 = one pupil wide and fixed
2 = eyelids closed but open to loud voice	2 = pupil or corneal reflexes absent
1 = eyelids closed but open to pain	1 = pupil and corneal reflexes absent
0 = eyelids remain closed with pain	0 = absent pupil, corneal, and cough reflex
Motor response (M)	Respiration (R)
4 = thumbs-up	4 = not intubated, regular breathing pattern
3 = localizing to pain	3 = not intubated, Cheyne -stokes breathing pattern
2 = flexion response to pain	2 = not intubated, irregular breathing
1 = extension response to pain	1 = breathes above ventilator rate
0 = no response to pain or myoclonus status	0 = breathes at ventilator rate or apnea

Figure 3. The FOUR scale. Adapted from Wijdicks et al., 2005¹².

of improvement. It should be remembered that the evaluation of reflexes also guides the examiner about alterations of upper or lower motor neurons. When evaluating the plantar response, it should be described whether it is neutral, in flexion or extension (Babinski reflex), which is another vital sign that may indicate upper motor neuron pathologies¹⁶.

In patients with neuroinfection or subarachnoid hemorrhage, a certain degree of nuchal rigidity on cervical flexion is frequent, or pain may also be experienced starting in the nuchal region and extending to the head and

interscapular region. In patients with suspected meningitis, it is critical to evaluate whether there is a pain in cervical flexion accompanied by flexion of the hips and knees (Brudzinski's sign) or pain in flexion of the knees when performing hip flexion (Kernig's sign)^{6,17}.

Comatose patient

Most patients in the ICU are in an altered state of consciousness and, in many cases, under invasive mechanical ventilation, so they cannot cooperate with the examiner,

Table 3. Impairment scale ASIA. Spinal cord injuries are classified in general terms of being neurologically “complete” or “incomplete” based on sacral sparing. Sacral sparing refers to the presence of sensory or motor function in the most caudal sacral segments

ASIA impairment scale	Description
A	Complete. No sensory or motor function is preserved in the sacral segments S4–S5.
B	Incomplete. Sensory but no motor function is preserved below the neurological level and includes the sacral segments.
C	Incomplete. Motor Function is preserved below the neurological level, and more than half of key muscles below the neurological level have a muscle grade < 3 (grades 0–2).
D	Incomplete. Motor function is preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade ≥ 3.
E	Normal. Sensory and motor functions are normal.

ASIA: American spine injury association.

and many of the maneuvers or strategies described above cannot be carried out. However, this does not mean that a neurological examination adapted to the patient's clinical conditions should not be performed¹⁸. As mentioned at the beginning of the chapter, the verification of the state of consciousness is the first step before continuing with the clinical evaluation and can be carried out through the GCS, which was created for the context of cranioencephalic trauma but has been used worldwide and is used in many contexts other than trauma. The patient may be with airway protective measures or due to ventilatory failure and not necessarily neurological. It is for this reason that the motor response is the most important since it allows the evaluator to identify if the patient can understand the order given, process the message, and generate the motor response that is indicated; when it is not possible, it is necessary to perform painful stimuli both centrally (supraorbital, trapezius, and sternum) and peripherally (nail matrix or subungual of the third finger of the hands) to identify what kind of movements the patient generates. It is essential to clarify that the minimum score is 3^{5,6}.

Taking into account the weaknesses of the GCS, the FOUR scale was created, which allows a more objective evaluation of patients with a poor verbal response, either because of their underlying pathology or because they are under mechanical ventilation; it consists of four

sections and as an essential differential point evaluates the respiratory pattern visualized in the ventilation equipment. It also examines eye-opening, extraocular movements, and following simple verbal commands. It has a minimum score of zero and a maximum score of 16^{16,18}.

When examining a patient with altered consciousness, it is essential to carefully study the pupil size and reactivity associated with vital signs and respiratory pattern because although it is not common (<20% of cases), they present Cushing's triad given by hypertension, bradycardia, and altered respiratory pattern indicating increased intrapressure that requires immediate medical or even surgical management of the same^{5,18}.

Once a cervical spine lesion has been ruled out, oculocephalic reflexes should be evaluated by performing rapid head movements and observing the movement of the eyes, which will typically move toward the side where the head is turned. Still, a few seconds later, however, if the gaze goes simultaneously with the head (wrist eyes), it is considered that they are abolished and should be interpreted as a lesion at the pontic level where the nuclei of the VIII PC are located^{8,19}. The oculovestibular reflex is evaluated with the instillation of water in the external auditory canal, initially at a temperature of 4°C and later with water at 27°C. The objective is to verify the nystagmus caused by the instillation of water and its rapid phase depending on whether it is hot or cold⁶. However, it is a cumbersome maneuver that is often omitted because it is not entirely standardized and familiar to ICU health personnel.

Conclusion

The semiology of the neurocritical patient is as broad as the patient who is outside the ICU; despite not having in all cases collaboration by the patient for the different maneuvers, it is possible to perform simple tests at the bedside that along with the rest of the physical examination, anamnesis and imaging and paraclinical studies help the physician to perform an initial approach and subsequently management directed to the type of pathology or injury that the patient presents. The medical student, generalist physicians, resident, and specialist must perform a daily neurological examination of their patients to identify small changes in the evolution and thus verify progress or deterioration that may require changes in the various medical behaviors¹⁸.

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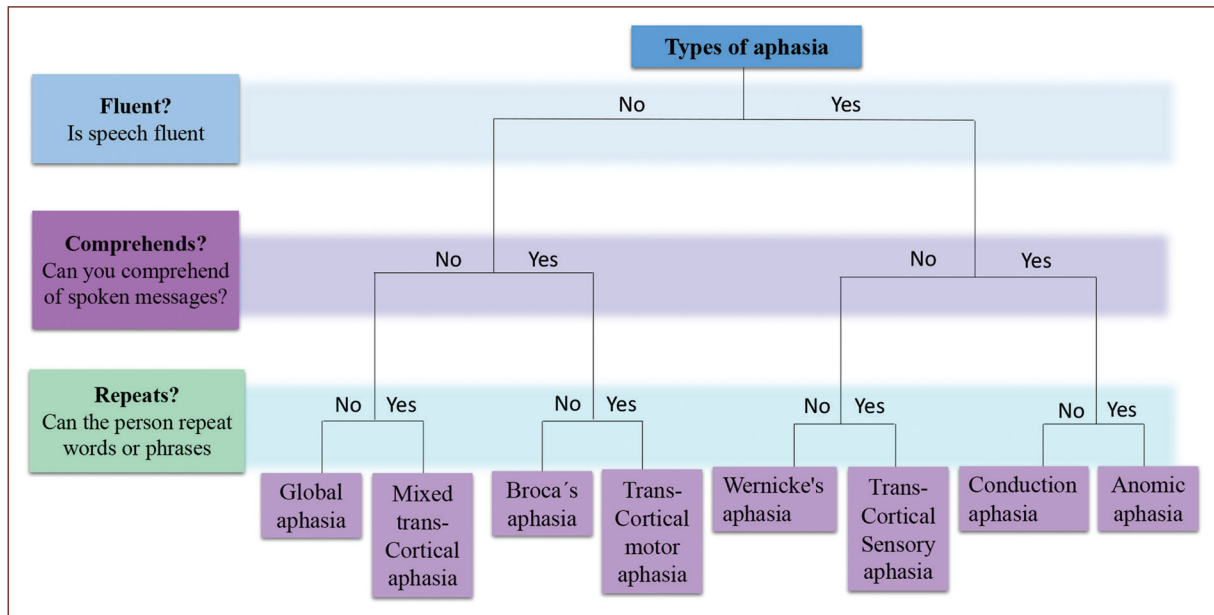


Figure 4. Assessment types of aphasia. Adapted from Wijdicks, 2022³.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that no patient data appear in this article.

Right to privacy and informed consent. The authors declare that no patient data appear in this article.

Use of artificial intelligence for generating text. The authors declare that they have not used any type of generative artificial intelligence for the writing of this manuscript nor for the creation of images, graphics, tables, or their corresponding captions.

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