The Logic of Clinical Reasoning in Medicine

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ABSTRACT
Three modes of inference underpin clinical reasoning: abduction, deduction, and induction. Abduction generates plausible explanations or diagnostic hypotheses at the outset of evaluation. Deduction guides the selection of tests to probe the consequences of those hypotheses and to assess whether the presumptive diagnosis accounts for all clinical findings. Induction then compares the hypotheses' predictions with observable facts to determine whether the expected findings are indeed present.
Keywords: Medical diagnosis; clinical reasoning; critical thinking.
Level of Evidence: V

La lógica del criterio clínico médico

RESUMEN
Los tres tipos de razonamiento que conforman el criterio clínico de los médicos son la abducción, la deducción y la inducción. La abducción se utiliza para generar explicaciones o hipótesis posibles al principio del proceso diagnóstico. El razonamiento deductivo se utiliza para determinar qué pruebas deben realizarse para explorar las consecuencias de las hipótesis y luego preguntarse si realmente el diagnóstico presuntivo explica todos los hallazgos. La fase inductiva compara las afirmaciones de la hipótesis con los hechos observables para finalmente evaluar si están presentes o no los hallazgos esperados.
Palabras clave: Diagnóstico médico; razonamiento clínico; pensamiento crítico.
Nivel de Evidencia: V

INTRODUCTION

Reaching a definitive diagnosis in a patient is a complex phenomenon because it involves dynamic and incomplete information. To address this, physicians use logic, evidence-based medical knowledge, and clinical experience to arrive at a diagnosis through a structured process.[1] This process is analytical and systematic and combines scientific aspects with deductive and inductive reasoning skills. This formula, known as the hypothesis method, consists of choosing one hypothesis among several alternatives.[2] More than a mere part of our medical legacy or an interesting historical and philosophical vestige, the hypothesis method is the cornerstone of diagnostic reasoning. In Phaedo, Plato formulated for the first time the hypothetical method that consists of choosing one hypothesis over other alternatives.[3] Undoubtedly, critical thinking predates clinical judgment.

Critical thinking is the cognitive tool used to analyze knowledge. Its application in medicine is called clinical reasoning. It requires both knowledge of disease and familiarity with the particular patient's clinical context, since critical thinking is used to discern and interpret both the scientific evidence and the patient's presentation.

The diagnostic process, like practicing a surgical approach, is always trainable and improvable. A long career is not a guarantee of good practice or *savoir faire*. It is an error to confuse experience with expertise and expert performance. The latter implies the correct interpretation of the available information and, therefore, proper execution. The logic of expertise cannot stand on its own; it must be articulated between scientific evidence and

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the information we obtain from our patients. The objectivity of scientific evidence is fundamental, since formal logic deals with the rules that govern inferences and focuses on the structure of arguments, but not on the truth of their premises. In the end, logic concerns itself with the structures and laws that govern meanings and relations among propositions, but it cannot go beyond these.

In most cases, well-trained subspecialists can reach the correct diagnosis with little effort using deductive reasoning alone. However, although pattern recognition can be an essential part of the deductive process, relying on it exclusively is likely to lead to diagnostic errors in less common diseases. Stereotyped diagnosis limits us to skill only in what is common, much like grandmothers who could recognize teething-related diarrhea in an infant.

To use deductive reasoning with minimal error, we must be aware of the logical fallacies into which the diagnostic process may fall. Correct diagnoses rest on valid reasoning as well as correct information. The shoulder specialist who disregards logic may naively assume that a diagnosis has been proven when, in reality, it has only been shown to be possible or probable. Knowing the logical basis of proof and refutation should help us not only to be more accurate in individual diagnosis, but also to provide a rational approach to developing diagnostic criteria supported by Evidence-Based Medicine.

The purpose of this article is to review the hypothesis method as it applies to medical diagnosis and to the application of clinical judgment.

FIRST IMPRESSION AND ABDUCTIVE REASONING

The expression abductive reasoning (or abductive judgment) refers to a form of logical reasoning that physicians (and others) use to formulate explanatory hypotheses based on incomplete observations. The concept was introduced and developed by the American philosopher and logician Charles Sanders Peirce and is defined as the process of inferring the best possible explanation from the available data.[4]

When the patient states the chief complaint, we can abduct from this history the possible causes and the etiopathogenesis of the illness. To achieve this, we resort to abductive judgment, because deductive and inductive reasoning by themselves are insufficient to explain and infer what occurs during the initial stage of the diagnostic process, when the physician must generate potential diagnoses and their possible causes, given that the information available cannot yet contribute to the development of explanatory theories. Abduction, as a form of creative inference, is used instead to generate possible explanations or hypotheses through the analysis of incomplete observations at the outset of the diagnostic process.

Abductive judgment rests on conditional probability, namely the probability that something occurs given that something else has already occurred. In practical terms, if a patient reports a fall from a bicycle and presents with a deformity of the clavicle, a fracture of that bone is to be expected. The analysis then proceeds to the recognition of key elements or sets of elements, such as “shoulder pain” or “active loss of mobility.” In this way, the formulation of abductive reasoning builds the foundations that will guide the next step in the process: deduction.

DEDUCTIVE REASONING

After the first impression furnished by abduction, the physician lists possible differential diagnoses; the scientist, hypotheses; and the detective, suspected criminals. Each recognizes that most hypotheses are incorrect and that the work consists in eliminating the incorrect ones and confirming the correct ones, two complementary yet very different processes. For example, the detective uses an alibi for elimination and motive or evidence of presence at the scene, or both, for incrimination. The scientist proposes a hypothesis, defines its implications, and then designs experiments based on these deductions. If the experiment confirms expectations, the hypothesis is supported. If the experimental results contradict the hypothesis, that hypothesis must be abandoned. On this point, José Manuel del Sel[5] wrote: “… Hypotheses in science are always conditioned by being refutable; unfavorable evidence must be sought conscientiously. The scientist does not try, nor does he grow upset if his theory is refuted, because it would be much worse to persist if it is fraudulent …”

Findings that are merely compatible do not affirm a diagnosis; they simply establish that it is possible. Conversely, if our presumptive diagnosis fails to explain the findings that emerge from the physical examination, it is likely because the diagnostic hypothesis has been incorrect, that is, the abductive reasoning has failed. In such a case, either we lack knowledge about the possible diseases the patient may have, or our history taking and initial assessment have been inadequate, or we have too hastily discarded other differential diagnoses.

Deductive reasoning is used to determine which tests should be performed to explore the consequences of the hypotheses. It applies a known general rule to a particular case. Here, we assume a hypothesis is possible, and the examiner must decide which clinical tests and ancillary studies are necessary to confirm or refute it. If predicted and observed results match, the hypothesis is supported but not confirmed, unless the examination findings are specific to that disease. If the findings cannot be explained by our diagnostic hypothesis, the hypothesis is rejected (Figure 1).

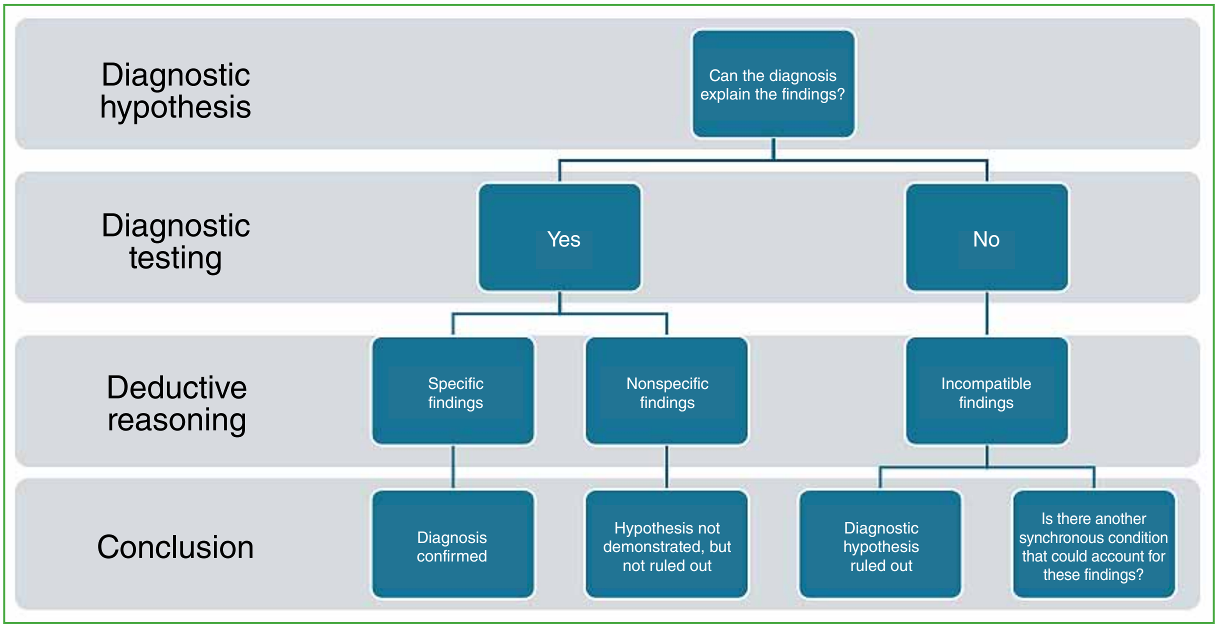

Figure 1. Does the diagnosis explain all the clinical findings?

INDUCTIVE REASONING

The physician tests each hypothetical diagnosis in turn, attempting to refute the incorrect and to prove the correct. To do so, two elementary questions are posed: does the diagnosis explain all the clinical findings, and are the expected findings present? If these findings are specific to the disease, we have reached a definitive diagnosis (Figure 2).

To answer the first question, we examine the particular case (the illness) to see whether it fits into a class (the disease or syndrome proposed as the hypothetical diagnosis). For the second, our perspective is reversed, and we examine the class to see whether the attributes of the class (diagnostic criteria) are congruent with the particular case (the illness).

Inductive reasoning complements this process by allowing the physician, through the systematic performance of diagnostic tests in different patients, to observe how different combinations of signs and symptoms are repeatedly associated with certain diseases. Thus, abstraction and generalization arise not only from clinical observation but also from the inductive interpretation of positive or negative results of specific tests according to the case. It involves abstracting findings, sowing clinical observations, and discerning what is common among what is diverse.

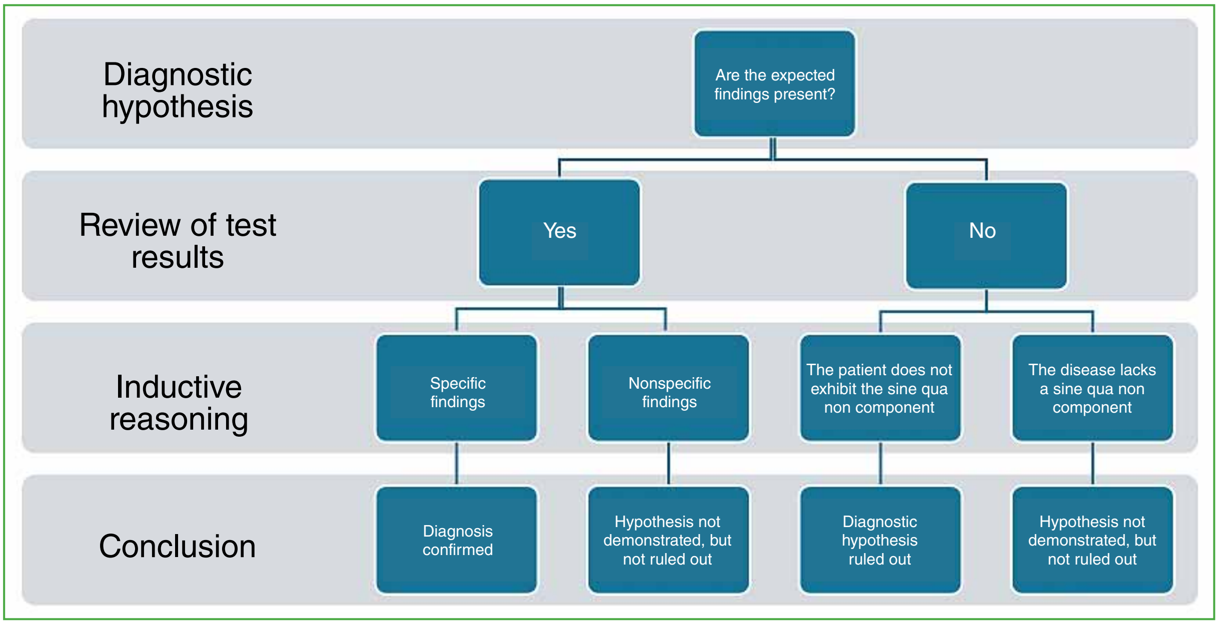

Figure 2. Are the expected findings present?

Jorge Luis Borges, in his short story *Funes the Memorious*, describes a main character who lacks this capacity for reasoning: "*I suspect, nevertheless, that he was not very capable of thought. To think is to forget a difference, to generalize, to abstract*. *In Funes' crowded world there were only details, almost immediate,*" thereby illustrating the epistemological importance of the ability to relativize and contextualize details in order to think in general terms. This is essential to build clinical judgment, identify patterns, and derive a diagnosis from the integration of multiple data.[6]

Figures 1 and 2 depict the path from test questions to proof or refutation. It is immediately evident that a highly specific test is used primarily to confirm a disease. Specificity measures a test's ability to correctly identify people who do not have the disease, thus avoiding false positives. If a test is highly specific and yields a positive result, it is very likely that the person actually has the disease, so the positive predictive value is high. Conversely, sensitive tests are used to rule out diseases, because they have a high capacity to detect people who do have the disease, thereby avoiding false negatives. It is also evident from Figures 1 and 2 that, on certain occasions, the physician may end up with neither confirmation nor refutation of the presumptive diagnosis in a strict logical sense.

Figure 3 indicates the relationship that may exist between a manifestation and a disease. A manifestation may be associated with a disease all the time (as a sine qua non condition), most of the time, occasionally, or never. Unlike deduction, induction does not provide logical certainties but clinical probabilities, so it must be complemented by statistical evidence and by linked, consecutive testing. Despite its relativity, it is essential for creating diagnostic criteria in daily practice.

REFUTING THE DIAGNOSIS BY INCOMPATIBLE FINDINGS

If the case presents incongruent features that cannot be explained in terms of the hypothetical diagnosis, then that differential diagnosis must be discarded. For example, if a patient presents with shoulder pain but lacks clinical manifestations (M1) considered fundamental (or sine qua non), such as asymmetric loss of shoulder abduction, shoulder-girdle atrophy, or scapular dyskinesia, we could initially rule out facioscapulohumeral muscular dystrophy, even if there is a hereditary history of this disease (Figure 4).

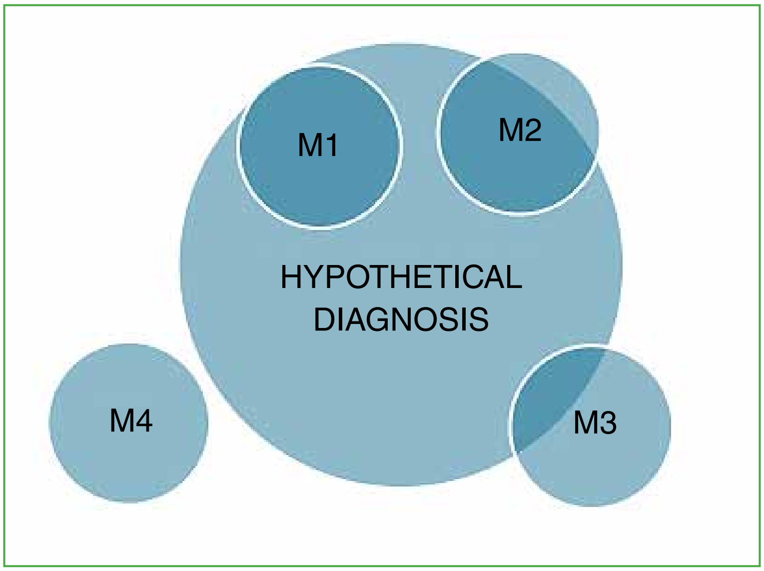

Figure 3. A manifestation of disease may be associated with a disease—and thus with a hypothetical or presumptive diagnosis—always (M1, *sine qua non* manifestation), most of the time (M2), occasionally (M3), or never (M4). In none of these cases is the manifestation uniquely specific or pathognomonic for that disease.

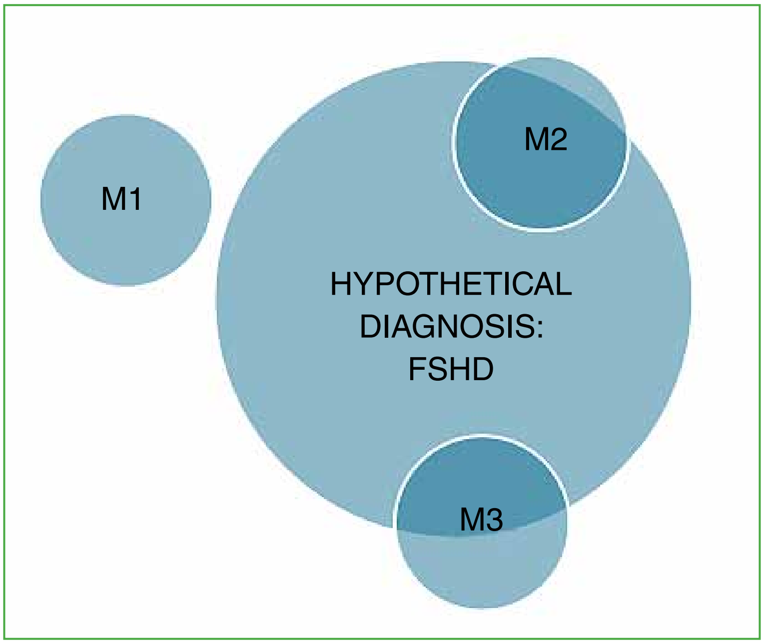

Figure 4. A hypothetical diagnosis can be discarded if a finding (M1) of the disease cannot be identified. M1 = asymmetric loss of shoulder abduction, shoulder-girdle atrophy, and scapular dyskinesia; M2 = facial weakness with asymmetric smile; M3 = sensorineural hearing loss. The absence of M1 is incompatible with the hypothetical diagnosis of facioscapulohumeral muscular dystrophy (FSHD).

However, the physician need not terminally reject the hypothetical diagnosis when encountering an unexpected manifestation. The unforeseen manifestation may be caused by a disease other than that indicated by the hypothetical diagnosis. This additional clinical manifestation may represent another synchronous disease, as can occur in a C5 radiculopathy coexisting with rotator cuff syndrome (Figure 5). If the manifestation can be attributed neither to the hypothetical diagnosis nor to a coexisting synchronous diagnosis, the physician should consider a new hypothetical diagnosis.

Beyond this clinical scenario, ideally multiple independent diagnoses should be avoided whenever possible because they compromise logical simplicity. The more complicated the hypothesis, the more difficult it is to verify its probability. This is known as the logical dictum of Ockham's razor. In the nineteenth century, Sir William Hamilton reformulated this principle as the "law of parsimony," which forbids, without proven necessity, the multiplication of entities, powers, principles, or causes. Its best-known formulation is *Entia non sunt multiplicanda praeter necessitatem*—entities are not to be multiplied without necessity—since simple theories are easier to prove or refute because they involve fewer variables and logical steps.[7] This makes errors, if present, easier to detect. In science, the capacity to refute a hypothesis is crucial. Therefore, although the simplest explanation is not always the correct one, simple models prevail over more complex ones.

Nevertheless, in older patients or those with prior conditions, Ockham's razor may lead to excessive simplification of clinical interpretation, premature diagnostic conclusions, and potentially suboptimal care.[8]

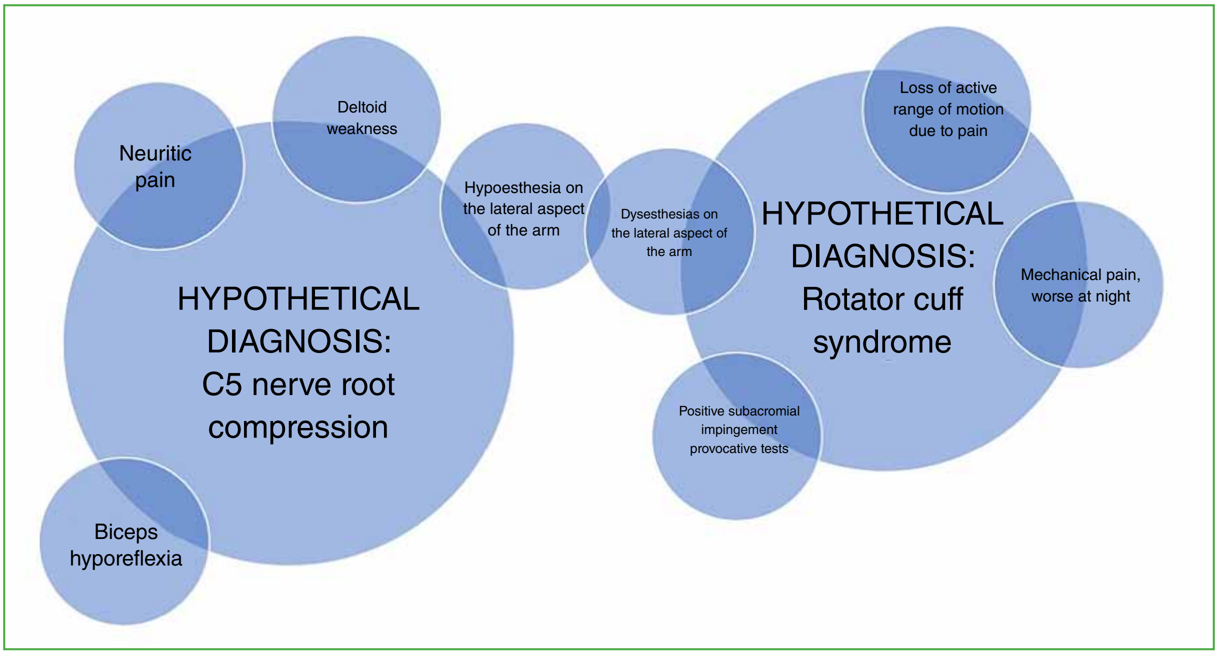

Figure 5. A C4–C5 cervical disc herniation could compress the C5 root and cause weakness of the deltoid and biceps muscles, decreased sensation along the lateral arm, and loss of the bicipital reflex. This lesion could coexist with rotator cuff syndrome, which causes lateral arm pain, loss of active mobility due to pain, mechanical pain with nocturnal worsening, and positive subacromial impingement tests.

PROVING THE DIAGNOSIS BY CONGRUENT FINDINGS

To claim a definitive diagnosis on the grounds that it could explain all the findings is to commit a logical fallacy: affirming the consequent.[9] For example, "If the supraspinatus tendon is completely torn, then the patient will have pain. If the patient has shoulder pain, it is because the supraspinatus tendon is completely torn." There are many other causes of shoulder pain unrelated to the rotator cuff, and the prevalence of supraspinatus tendon lesions in asymptomatic individuals is high, so this reasoning is false.

A diagnosis is proven only when the clinical findings, considered as a whole, are attributable exclusively to the hypothetical diagnosis and to no other disease. Unfortunately, few clinical findings are pathognomonic; otherwise, the diagnostic process would be straightforward. For instance, the combination of mechanical pain with nocturnal worsening and loss of active mobility does not confirm rotator cuff syndrome.

When there is no single pathognomonic finding, such as a Popeye sign attributable to a lesion of the long head of the biceps, a combination of findings considered together may serve the same function. While a single clinical manifestation may not be pathognomonic, the combination may be specific to a condition. This is the rule in most clinical presentations and their corresponding diseases (Figure 6).

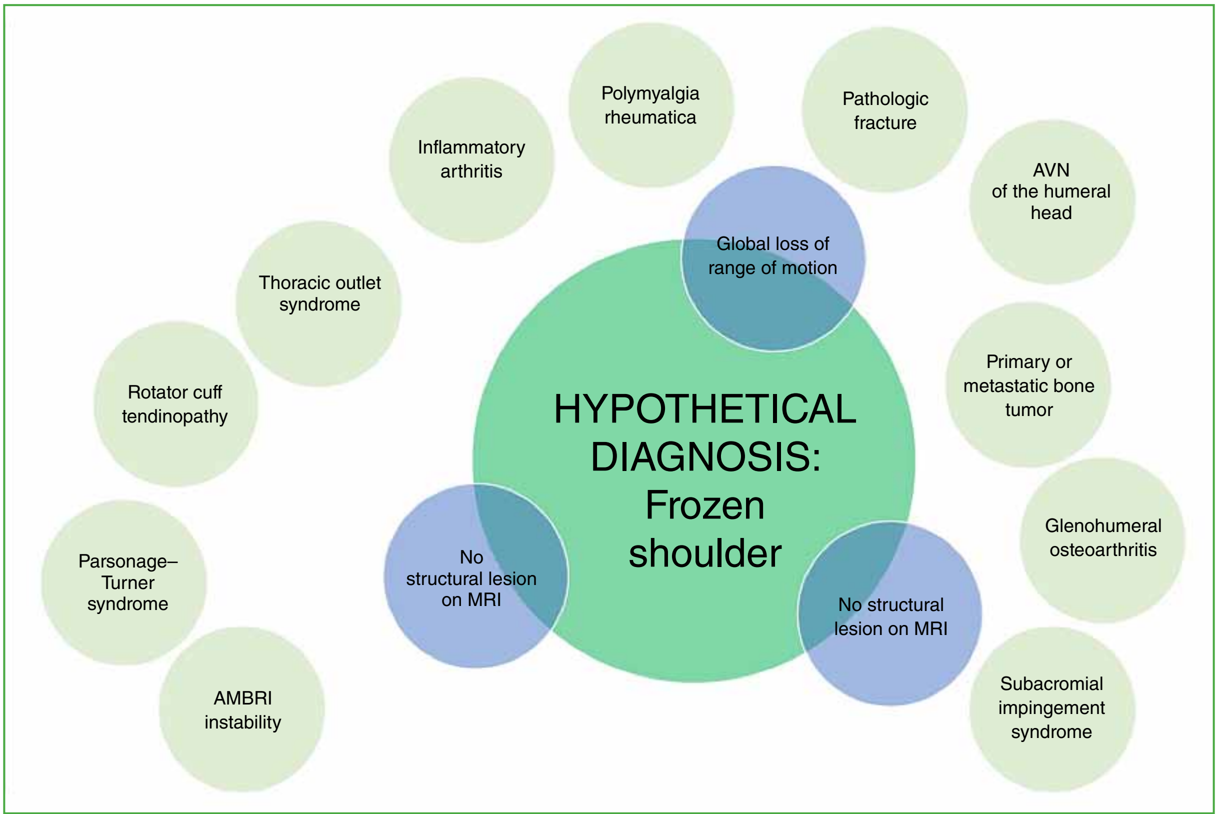

Figure 6. Shoulder pain, loss of active and passive motion greater than 50 percent, absence of a traumatic history, and imaging that rules out a structural lesion are individually nonspecific. However, their combination is specific for frozen shoulder.

ARE THE EXPECTED FINDINGS PRESENT?

Refuting the diagnosis by absence of the expected findings

Can the combination of clinical manifestations that characterizes the hypothetical diagnosis be found in the case at hand? Refutation of a diagnosis by failure to find an expected finding is logically valid only if the expected finding is always present in the disease in question, as in a *sine qua non* condition. For example, a patient with a history of a bicycle fall who has pain at the distal end of the clavicle but no "key-sign" deformity will not have a complete injury of the coracoclavicular and acromioclavicular ligaments, since the presence of that deformity is a sine qua non feature of Rockwood grade 3, 4, and 5 acromioclavicular dislocations.[10]

PROVING THE DIAGNOSIS BY THE PRESENCE OF THE EXPECTED FINDINGS

It is logically false to claim that a diagnosis has been proven simply because the expected manifestations are present. The claim requires that the combination of manifestations be unique; otherwise, the fallacy of affirming the consequent has been committed, as discussed above.

If a disease always causes a given clinical finding, then that manifestation (*sine qua non*) must be present or the diagnosis is refuted. But the presence of a sine qua non manifestation does not prove the diagnosis. Proof requires that the findings be unique (pathognomonic), not merely essential. A manifestation that is only sometimes found in association with a disease may be used to affirm its presence if that manifestation meets the prerequisite of uniqueness. Such a finding could be, for example, calcific tendinopathy of the rotator cuff in a patient with shoulder pain.

Experience (and inductive inference) does not yield judgments with true and strict universality, but rather with assumed and relative generalization. In this sense, evidence-based medicine offers statistical and therefore probabilistic knowledge. The frequency with which particular manifestations associate with a disease does have affirmative value. If we find manifestations with a high statistical association with the hypothesized diagnosis, our argument is stronger than if the manifestations are rarely associated. The more such manifestations we identify, the more confidently we may affirm the diagnosis. For example, in a patient with diabetes and hypothyroidism, the likelihood of frozen shoulder is much higher if sudden, atraumatic pain is associated with a global loss of mobility.[11]

The ideal clinical manifestations to validate our diagnostic hypothesis will be those that, taken together, are highly specific and statistically associated with the disease. If we select a group of manifestations with these attributes, we will have developed diagnostic criteria. As noted, this is achieved through pattern recognition, categorization, and hypothesis testing. If we fail to achieve certainty through this method, we must persist in the search rather than deny contradictory evidence in order to choose an unrealistic hypothesis.

CONCLUSIONS

Medical diagnosis is a complex process. To accomplish it, physicians employ logic, knowledge, and experience through the hypothesis method, which consists of choosing the best explanation among several alternatives. This method is grounded in critical thinking, applied in medicine as clinical reasoning.

The diagnostic process combines three modes of reasoning: abductive, deductive, and inductive. Abductive reasoning allows hypotheses to be formulated from incomplete and dynamic observations, establishing possible explanations based on conditional probability. Deductive reasoning then evaluates which tests would confirm or refute the hypothesis, eliminating incorrect diagnoses. Finally, inductive reasoning analyzes whether the clinical findings match the hypothesized diagnosis.

Diagnostic errors may arise from overreliance on pattern recognition without considering exceptions or from ignoring logical fallacies. The objectivity of scientific evidence is key to avoiding misdiagnosis. Diagnostic error is not inevitable, and accuracy improves with the proper use of logic, scientific evidence, and systematic patient evaluation.

Conflicts of interest: The authors declare no conflicts of interest.

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