



UPDATE IN RADIOLOGY

Evidence-based radiology for diagnostic imaging: What it is and how to practice it[☆]

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Abstract Evidence-based radiology is defined as the decision that results from integrating clinical information to select the most appropriate imaging test on the basis of the best available evidence, the physician's experience, and the patient's expectations. The practice of evidence-based radiology consists of five steps: formulating the question, performing an efficient search of the literature, critically evaluating the literature, applying the results of the search and evaluating while taking into account the patient's values, and evaluating the results obtained within our own practice. In diagnostic imaging, the number of resources available for evidence-based radiology is increasing: apart from books, articles, and web pages on this subject, evidence-based radiology is receiving more attention at diagnostic imaging conferences. The principles of evidence-based radiology will help promote the appropriate use of resources, greatly benefiting patients (decreasing the use of examinations that use ionizing radiation), professionals (less overload), and managers (more efficient use of resources).

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PALABRAS CLAVE

Medicina basada en la evidencia;
Radiología basada en la evidencia;
Diagnóstico por imagen;
Criterios ACR;
ALARA

Radiología basada en la evidencia en el diagnóstico por imagen: ¿qué es y cómo se practica?

Resumen La Radiología Basada en la Evidencia (RBE), se define como la decisión que resulta de integrar la clínica con la prueba de imagen más adecuada en base a la mejor evidencia disponible, la experiencia del médico y las expectativas del paciente. Su práctica consta de cinco pasos: formular la pregunta, realizar una búsqueda eficiente de la literatura, evaluar críticamente la literatura, aplicarla a los resultados teniendo en cuenta nuestra experiencia y los valores del paciente y evaluar los resultados obtenidos dentro de nuestra práctica. En Radiodiagnóstico se está incrementando el número de recursos disponibles de RBE, encontrando actualmente libros, artículos, páginas *web*, así como potenciando actividades en congresos de nuestra especialidad. Los principios de la RBE ayudarán a promover el uso apropiado de los recursos, aportando enormes beneficios a pacientes (disminuye el uso de las exploraciones que utilizan radiaciones ionizantes), profesionales (menos sobrecarga) y gestores (uso más eficiente de recursos).

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Introduction

The term "Evidence-Based Medicine" (EBM) was created by the Evidence-Based Medicine Working Group at the McMaster University in Hamilton, Ontario (Canada)¹ in the early 90s. This group was proposing to carry out a clinical practice based on the best results of an investigation and to train clinicians the skills to perform an efficient search and a critical appraisal of articles in order to make their research tasks easier. The National Health Service Centre for Evidence-Based Medicine (CEBM)² in Oxford, UK, has been the second group to apply this concept.

Although the first articles on critical appraisal³⁻⁵ were published in the *Journal of the JAMA* already in 1993, it was not until 1996 when Sackett formally introduced the term EBM as "conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients".⁶

In recent years we have witnessed an enormous increase in the number of diagnostic examinations using ionizing radiation. Data published in the United States show an increase higher than 600% per decade: from three million computed tomographies (CT) during 1985, to more than sixty million CT in 2005.⁷

Are all these examinations really necessary or could they mainly be avoided? There are increasingly more articles published that state the overuse of diagnostic tests.⁸ Unnecessary studies contribute to an increase in health care costs and lead to a rise on the adverse effects that entail ionizing radiations, being this the most important fact in pediatric population.⁹⁻¹¹ Moreover, an unnecessary test can also cause anxiety to the patient, and in some cases, a casual and insignificant finding can lead to other examinations and radiology follow-up that in no case will contribute to increase survival rates or to improve life quality.¹² All of these are moving us away from the principle ALARA (As Low As Reasonably Achievable), which implies that studies must only be performed when really required and using the minimum dose necessary to achieve a diagnostic conclusion.¹³

Although it has taken a few years for the term EBM to be established, it is nowadays a basic pillar in the practice of medicine. The EBM can be used every time there is any doubt on a treatment, diagnosis, intervention or prognosis on a specific patient.

Due to the fact that we are daily under the obligation to make many decisions, the use of EBM allows us to identify, evaluate and apply relevant information so that decisions are made systematically and represent the combination of personal expertise, experience and clinical or radiologic knowledge with the best external evidence revised during the research.¹⁴

Many of the questions raised by clinicians are on imaging diagnosis: How often should a follow-up CT on a lymphoma in remission be made? Is it urgent to perform a CT to evaluate a patient with a several month history of cephalalgia? In these occasions, clinicians and radiologists must make a team to find solutions to solve individual patients' problems and optimize resources.

It is in this context that we should talk about evidence-based radiology (EBR), which is defined as the decision that results from integrating clinical information with the

most appropriate imaging modality on the basis of the best available evidence, the physician's experience, and the patient's expectations.¹⁵ In other words, the purpose of EBR is to select the most effective diagnostic technique taking into account the values and circumstances of a given patient.¹⁶

Levels of evidence and grades of recommendation

The levels of evidence were set with the aim to help professionals assess the strength or robustness of the results obtained in a research. It is a hierarchical classification according to the scientific rigor of the design of studies. There are five levels of evidence that range from level 1 (best evidence) to level 5 (least solid evidence). From this classification, levels of recommendation are established concerning a specific health care procedure or intervention: A (highly recommendable), B (recommendable), C (not very recommendable) and D (not recommendable).¹⁷

From one given disease, different types of questions can be raised that can relate to its etiology and risk factors (what causes this disease?), to its frequency (how common is this disease?), to its diagnosis (has this patient this disease? or what is the best test to confirm or rule out the diagnosis of suspicion?), to its prognosis (which one of these patients will develop this disease?), or to its treatment (what is the best treatment?). Different studies will be designed depending on the type of question to be answered.¹⁸

Therefore, Oxford's CEBM² sets the levels of evidence and grades of recommendation depending on whether the questions to be reformulated are regarding treatment, prognosis, diagnosis or economic analysis. [Table 1](#) shows the classification of levels of evidence and grades of recommendation for diagnostic tests.

According to the design of the studies, they can be classified as observational (the researcher is prospectively or retrospectively a spectator of what is happening) and experimental (the researcher controls the factor under study).¹⁹

Within the observational studies there are the cohort studies, the case-control studies and the transversal or prevalence studies.²⁰

Normally, an observational study with an outcome variable (disease determined by a reference test or gold standard) and a predictive variable (test under study) is brought up in order to evaluate diagnostic tests. Therefore, in CEBM's classification ([Table 1](#)), the design of study considered the most appropriate in order to compare two diagnostic tests is the cohort study (level of evidence 1b). Although even better than a cohort study is a systematic review (SR) of various cohort studies. A SR performs a systematic search of all studies on a subject, appraises them critically and summarises the outcome according to a set of predetermined criteria.²¹ A meta-analysis always includes a statistical treatment of data, whereas a SR may not.

Case-control studies can be applied in radiology although their use is not very extended. Cost-effectiveness studies are increasingly common in our field.²²

Table 1 Classification of levels of evidence and grades of recommendation for diagnostic studies according to Oxford's CEBM.

Grade of recommendation	Level of evidence	Type of study
A (highly recommendable)	1a	Systematic reviews or meta-analyses from level 1 studies, which fit the homogeneity criteria ^a
A (highly recommendable)	1b	Cohort studies that compare blindly and independently an appropriate group of consecutive patients. The diagnostic test under study and the reference standard are applied to all patients
A (highly recommendable)	1c	Diagnostic studies with high sensitivity and specificity
B (recommendable)	2a	Systematic reviews of level 2 studies that fit the homogeneity criteria
B (recommendable)	2b	Cohort studies that compare blindly and independently a group of nonconsecutive patients or reduced to a narrow group of individual studies, to whom the diagnostic test and the reference standard is applied
B (recommendable)	3a	Systematic reviews that match the homogeneity criteria for level 3 studies or higher
B (recommendable)	3b	Blind and independent comparison of an adequate group of nonconsecutive patients, not applying the reference standard to all patients
C (not very recommendable)	4	Case-control studies or reference standard studies not applied independently or blindly
D (not recommendable)	5	Expert's opinion without critical appraisal of the literature

Source: Centre for Evidence Based Medicine at the University of Oxford website².

^a Homogeneity: the results from the different studies must be treated similarly, deleting the possible variations that might exist between individual studies.

How is the EBR practiced?

The creation and evolution of Internet have allowed the development of the practice of EBR in a way that any radiologist who has a question can perform an efficient search of the relevant literature, select the studies that provide a higher level of evidence, critically appraise them, apply the conclusions of the study to their daily practice and evaluate the impact of that specific implementation.²³

The practice of EBR establishes five steps:

Step 1: formulate a question

EBR is expected to offer useful solutions to specific clinical problems by achieving valid and current information in order to take decisions on our patients.^{24,25}

Formulating a question is the most important step within the process. It requires thorough thinking on it and making it, since it will be the starting point. Normally, within diagnostic radiology the majority of questions relate to the superiority of an imaging modality over another regarding a specific pathology.³

When formulating a question it must be divided into little pieces to facilitate the subsequent search of an answer within the literature. A well-structured question consists of four parts²⁶:

- Define the patient, group of patients or the problem of interest.
- Define the intervention (in our case the diagnostic test) to be evaluated.
- Compare the test to be evaluated with the one considered the standard reference (gold standard) (if any).
- Define the outcome or result to be evaluated.

Thus, following the acronym PICO ("P" patient; "I" intervention; "C" comparison; "O" outcome), the question will be ready for the search.

Let's imagine that we are on call and we get a call from the ER about a 35-year-old patient who after a thoracic trauma of high impact presents central thoracic pain and hypotension. The chest radiograph is normal. Should any other tests be done? Is the chest radiograph enough to diagnose or rule out an aortic rupture or would it be better to perform a CT?

In this example, the four parts of the question would be: "P" thoracic trauma; "I" chest radiograph; "C" computed tomography; "O" aortic rupture diagnosis. This clinical setting could also be solved by formulating a multiple-comparison question that would be as follows: in patients with a suspected aortic rupture trauma, are the chest radiograph, the computed tomography and the aortography equivalent for the diagnosis of the presence, severity and level of rupture?

Step 2: find the best possible evidence

Once the question has been formulated, we must know where to search for the most relevant literature and how to do it in a fast and efficient way.²⁷

In the search for information, we radiologists are faced with an enormous volume of literature on diagnosis that is published not only in journals specialized in radiology but also in journals of other specialties.²⁸ Where should we start from?

In order to classify the different types of information, Haynes proposed a few years back the model of "the pyramid of evidence" in which a hierarchy of all literature available would be established. At the beginning, it had four levels called "4S"²⁹: the foundation was made of the

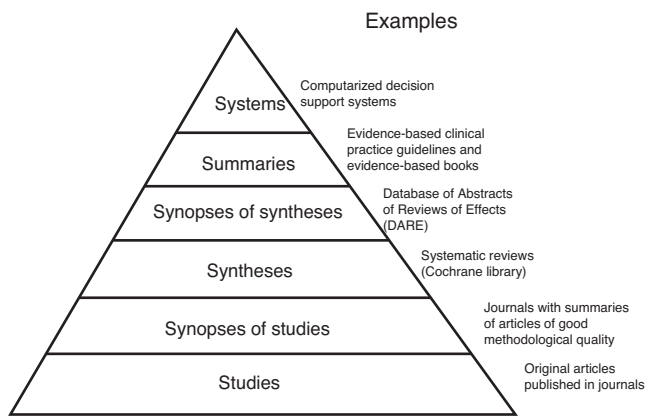


Figure 1 Pyramid of evidence "6S". Adapted from the original of DiCenso et al.³¹

primary sources (original studies) and in higher levels were the secondary sources (synthesis, synopsis and information systems). Subsequently, this pyramid was redefined into five steps³⁰ and it now has six levels (model "6S" of the pyramid of evidence)³¹ (Fig. 1).

How can this pyramid guide the professionals who must take a decision so that they can find the evidence needed in a fast and safe way?

Normally, secondary sources are better than primary; therefore, the literature that appears in higher steps is considered scientifically better than that of lower levels. The search for evidence must start at the highest possible level of the pyramid.

At the vertex are the support systems for clinical decisions, computerised decision support systems, which are computerised information systems used to integrate clinicians and patient information with the aim to take decisions regarding their care.³² They summarise all the relevant and important evidence on a clinical problem and generate specific recommendations for a given patient after having introduced the details in the program. This system is for example being used in the United Kingdom to manage oral anticoagulation.³³

In radiodiagnosis there is not at present a clinical decision support system, although there are already some studies that evaluate the impact that its development would have.³⁴

The summaries are on the next level. They integrate the information based on evidence regarding a specific problem and are updated regularly. ClinicalEvidence³⁵ and UpToDate³⁶ are examples of these summaries. In this group there are also the clinical practice guidelines based on evidence, such as the ones found in The National Guidelines Clearinghouse.³⁷

When there is no summary the next step is to search for the synopses of synthesis, which summarise and group the SR data. The synopses of synthesis are, in other words, a systematic review of systematic reviews that meet inclusion and exclusion criteria. They consist of a summary (synopses) of the corresponding SR and are accompanied by comments on the methodological quality of the SR and their applicability in daily practice. These synopses of synthesis can be found in the ACP Journal Club³⁸ and Evidence-Based Medicine.³⁹ Another source can be found in the Center for

Reviews and Dissemination (CRD) at the University of York,⁴⁰ which is a database that in itself contains three databases. One of them is the Database of Abstracts of Reviews of Effects (DARE) that contains structured summaries of RS that meet quality criteria.⁴¹

If these synopses of synthesis do not exist or are insufficient, then we should turn to the basics of SR, which can be available in EvidenceUpdates⁴² and Cochrane Library,⁴³ and contain synthesis on the effectiveness of health care interventions and some diagnostic tests.

If we cannot find what we are searching for, the next step is the synopses of the original studies. The advantages of a synopsis of an original study over just an original study are that they are briefer, have an added comment and have passed a quality filter and clinical relevance filter.

Finally, if we cannot find the answer in the secondary literature, we must search within the original studies of databases or primary sources such as Pubmed.⁴⁴

Step 3: critically appraise the literature

Once having defined the question to be answered and having identified the relevant literature, we must consider the design of the studies to be critically appraised since we will establish our levels of evidence and grades of recommendation around it (Table 1).

Imagine that we found a SR of cohort studies that concluded that aortic CT is not superior to chest radiography for the diagnosis of an aortic rupture. Since this design represents the highest level of evidence, should we just believe it? Apart from the design, we should also raise other questions to establish if the results and conclusions of the research are valid and applicable. We must therefore critically appraise it.

In an article on diagnosis, the three key questions to be formulated are to determine whether the results of the study are valid, what those results are and if they are applicable to our setting.^{45,46} We must therefore read with careful attention the materials and methods section, and the results section.

Are the results on the study valid?: materials and methods section

Was there a comparison between the test being evaluated and the one considered reference standard? The most correct procedure is to apply the reference standard test on all patients, regardless of the result of the test being evaluated. It is also important to find out whether it existed a blind comparison between both tests, that is, if those who interpreted the results of the test under study were aware of the results of the reference standard test (and vice versa).

Did the test include a proper spectrum of patients?

The article must explain how the subjects were recruited and define the inclusion or exclusion criteria followed.

Is the test clearly described?

It must be clearly defined as what are a positive result and a negative result. Furthermore, it is especially important in imaging studies to describe the technical aspects in order that the test can be reproduced in another department. Additional aspects to be taken into account are for example exposure to radiation. The

Table 2 Formulae necessary to interpret a diagnostic test.

	Reference standard	
	With the disease	Without the disease
<i>Test to be evaluated</i>		
Positive	TP	FP
Negative	FN	TN
	Sensitivity = $TP / (TP + FN)$	
	Specificity = $TN / (FP + TN)$	
	Positive predictive value = $TP / (TP + FP)$	
	Negative predictive value = $TN / (FN + TN)$	
	Positive likelihood ratio = $S / (1 - E)$	
	Negative likelihood ratio = $(1 - S) / E$	

FN: false negatives; FP: false positives; TN: true negatives; TP: true positives.

justification/optimization concept is important for the radiation protection of patients.⁴⁷

What are the results?: results section

Statistical analysis represents a problem to the majority of clinicians. Although this is a general article, some basic concepts that will be useful when interpreting a study on diagnostic tests must be defined.

Can likelihood ratios be calculated? The studies on diagnostic tests, set out an outcome variable (disease determined by an adequate reference test) and a predictive variable (test under study).¹⁸ The aim is to measure the strength of association between both tests using the sensitivity (percentage of patients with the disease who have a positive test) and specificity (proportion of healthy people with negative tests) so that the ability of a test to correctly classify a person according to the presence of a disease can be quantified (Table 2).

The positive predictive value (likelihood of disease presence with a positive test) and the negative predictive value (likelihood of healthiness with a negative test) can be calculated from the sensitivity and the specificity.¹⁸

Likelihood ratios, which unlike predictive values do not vary depending on the prevalence of the disease, can also be calculated. They can also be positive or negative:

- Positive likelihood ratio: indicates how more probable a positive result is in sick patients than in healthy ones. It should desirably be higher than 1.
- Negative likelihood ratio: indicates how more probable a negative result is in sick patients than in healthy ones. It should desirably be lower than 1.

All these association measures will allow us to interpret the clinical applicability of a test under study.

What is the accuracy of the results? In order to achieve this accuracy we must calculate the confidence intervals, among which the estimate that we are searching for can be found (the exact value cannot be known) with a defined degree of certainty (95%, 99%).

Can the results be applied to our setting?

Will the reproducibility of the test and its interpretation be satisfactory in our setting?

We must consider whether the scope of the test is too different from our setting.

Is the test acceptable in this case?

We must consider the availability of the test, its risks/discomfort and the costs.

Will the results of the test change our management?

From the clinical setting, if the approach is not going to change, the test will not be useful.

We must consider a treatment threshold and a pre-test probability and post-test probability of disease.

Step 4: apply

Once major evidence for the clinical question has been found, the next step is to use our own clinical experience and apply it to the values and preferences of the patient.

Before we decide whether to apply the results of our study to our patient, we must assess⁴⁸:

- If the diagnostic test can be reproduced in our unit.
- Consider the available alternatives.
- Calculate the pretest probability of our patients, that is, the probability that the patient has the disease (or condition) before performing the test or diagnostic test.
- Check if the patient or the group of patients is similar to the subjects of the study. The main features that can affect our decision include the stage or severity of our patient's disease. Other factors such as age, sex and comorbidity are also important.
- Weigh up the pros and cons of the diagnostic test for every patient.

In some occasions, the application of the evidence to patients is called "external validity", in other words, the generalization of the results obtained from our research.

Step 5: evaluate

The last step is to evaluate the results within our own clinical practice.⁴⁹ This can be achieved by evaluating effectiveness and efficiency. This is very important because the results obtained in specialized centres can differ from those obtained locally and therefore need to be evaluated locally.

Specific resources of evidence based Radiology

Books

The authors Medina and Blackmore have written two books on EBR. The first one is then called *Evidence-Based Imaging: Optimizing Imaging in Patient Care*,¹⁵ which include thirty chapters that evaluate the diagnostic options for different diseases. On the same line, these authors published recently a book about EBR in pediatrics.⁵⁰ It can also be useful when writing or critically appraising a study the book *Biostatistics for Radiologist*, written by Sardanelli and Di Leo,⁵¹ which includes basic definitions on statistics, design of studies and statistical calculations necessary to design and interpret an article on radiology.

Journal articles

More and more journals include articles about different aspects of EBR. The journals *Radiology*, *Seminars in Roentgenology* and *Academic Radiology*, among others, have published a series on the different steps in EBR.

SR and meta-analyses on diagnostic tests can be found not only in journals on other specialities^{52,53} but also in those specialized in radiology.^{54,55}

Furthermore, there are more articles that follow the service model question-answer, in other words, they are written like a structured answer to a specific clinical question; Critical Appraisal Topic (CAT). After formulating the clinical question, there is an explanation of the searching strategy that has been used and the articles selected that can best answer it through a summary of results. Finally, a comment on the design of the study and its applicability is included. Thus, they follow an EBM methodology. Although in their preparation they are not as complex as a SR or a meta-analysis, they are a useful tool.

Some examples of CAT can be found in journals such as The Canadian Association of Radiologist Journal,^{56,57} *Seminars in Roentgenology*^{58,59} and *Abdominal Imaging*.^{60,61}

Websites

<http://www.evidencebasedradiology.net>⁶² is a site developed by radiologists from Ireland, which provides an up to date practice of EBM. It has a free access section (where the EBR steps are explained) and a private part containing numerous links to articles and other electronic resources.

<http://radiologiaevidencia.org>⁶³ is a Spanish site still under construction that is aiming to have more than 1000 references all coming from secondary literature classified by organs and systems. It has a general part and links to other articles and resources. It could be accessed free and will be available in Spanish and English from June 2011.

<http://www.aur.org>⁶⁴: The Radiology Alliance for Health Services (RAHSR) in collaboration with the Association of University Radiologists teaches courses about critical appraisal of articles, cost-effectiveness analysis, clinical investigation, advanced statistics, quality of life and screening.

<http://www.acr.org>⁶⁵: the American College of Radiology, started to develop in 1990 the Appropriateness Criteria, which are guides on clinical practice. In order to create these guides, a committee of experts meets to prepare various clinical settings, searches for relevant literature to answer them, critically appraises them and they finally applies them to that setting.⁶⁶ Thus, a table with a list of recommendations is drawn up prioritizing among the different diagnostic tests within each clinical setting. The range runs from 1 (the least recommendable) until 9 (the most recommendable). Apart from the table there is also a summary of the literature consulted from which this decision has been made and the most relevant bibliography. Although methodologically they follow the five steps of EBR, there are some limitations to these criteria.⁶⁷ One of them is that there is no explanation about the searching strategy used: the inclusion and exclusion criteria used by the authors to establish a recommendation are not mentioned. Another important limitation is that a critical appraisal of the articles is not carried out, therefore it cannot be ascertained whether the chosen articles represent a good methodology. There is much variability regarding the design of the studies: they may include from a meta-analysis or a SR well developed, to an opinion article from an expert. For all that, although they are good tools we must use them with precaution since they may be seriously biased. Although they have been established for over 20 years, they have not been well disseminated among the medical community and therefore are not known or applied by the majority of clinicians.⁶⁸

Workshops and presentations in congresses

- European Society of Radiology: in the Congress held in Vienna in 2009, an EBR European Working Group was established, subject to The European Network for the Assessment of Imaging in Medicine (EuroAIM), which in turn is part of The European Institute for Biomedical Research (EIBIR).⁶⁹ This working group is lead by Professor Francesco Sardanelli (Milan, Italy) and has 42 members from 12 different countries. During this year, they have sufficiently studied which subjects in radiology have been studied by a SR or a meta-analysis and which have not, assessing the quality of these studies. Another one of their objectives is to create a young group with educational purposes.
- European Society of Gastrointestinal and Abdominal Radiologist: they are including EBR workshops in their annual congresses.⁷⁰

Discussion

The EBR presents limitations although at the same time it provides great benefits.

It has been pointed out that the practice of EBR takes much time and energy⁷¹: it is easier when we are asked to perform a test, with no discussion, instead of performing a search and argue the pros and cons of carrying it out. It may be so the first few times, although if this systematic work is incorporated to our usual practice there can be more material and available resources that might help more colleagues. In some occasions, it can also seem to threaten

the autonomy and freedom of physicians since they must follow "strict" action guidelines far from it. Guidelines are set as recommendations, but above those recommendations is our "individual clinical experience". In other words, if a guideline revising a specific pathology in a defined group of patients establishes a recommendation and our experience tells us the contrary, we are under no obligation to follow it.

A real limitation present is that the field of the imaging tests has not been sufficiently explored by studies that follow EBR principles. However, there is a great effort to identify which are the areas with more deficiencies within radiology in order to avoid this problem. This is a slow and expensive process but it must be pursued little by little without giving up on the way.

All these aspects start from a common premise: training is required in order to learn how to raise questions correctly, carry out efficient search strategies and critically appraise the literature in order to decide whether to apply it or not.

The fast incorporation of new technologies, the increase in the demand of services and the absence of quality scientific evidence have led to an increase in the variability of criteria for the use of specific diagnostic procedures. This variability can cause an overuse in some places and an underuse of the mentioned procedures in other places.⁷²

All these facts generate doubts about the quality of the care given to patients and cause the need to look for strategies and methods to develop agreed criteria that will help in decision taking on the use of specific procedures in clinical practice.⁷³

One of the most used tools in which the EBM methodology is based on is the one created by the Research AND Development Corporation together with the University of California Los Angeles, who established the RAND/UCLA Appropriateness Method. This method is based on the synthesis of evidence and on the experts' opinion and is used to establish whether the execution of a procedure on a specific patient can be appropriate, inappropriate or doubtful within certain clinical circumstances. Not only RAND but also the use of other evaluation methods pretends, among other things, to provide the tools that can be applied in medical practice and have been used in treatment and diagnostic aspects.⁷⁴ As for diagnosis, this method has been used to analyse the appropriate use of certain techniques such as endoscopy and colonoscopy,^{75,76} but there have not been found other studies on other types of diagnostic procedures. Although the American College of Radiology uses the methodology of the criteria of appropriate use they do not evaluate a technique but a specific clinical setting in which the different tests that could be performed are evaluated. The diagnostic tests could therefore constitute an area of development for the adequate use of studies.

Conclusions

The principles of EBR can be applied to all aspects of radiology and will help promote the appropriate use of imaging procedures.

A practice based on the principles of EBR contributes with enormous benefits not only to patients (less examinations using ionizing radiations) but also to professionals

(less medical overload) and to managers (more efficient use of resources). This is a change of mentality and practice that concerns the whole radiological community, not just one person.

Conflict of interests

The author declares no conflict of interests.

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References

1. McMaster University Web Site: Health Information Research Unit. Evidence Based Health Informatics. Available from: <http://hiru.mcmaster.ca/hiru/Default.aspx> [accessed 2010 Oct 25].
2. Center for Evidence Based Medicine at the University of Oxford Web Site. Available from: <http://www.cebm.net/index.aspx?o=1025> [published 1995 Jan 10; updated 2009 Feb 5; accessed 2010 Oct 17].
3. Chalazonitis AN, Tsimitselis G, Tzovara J, Mariolis A, Alevizos A, Pavi E. Evidence-based medicine and radiology. *JBR-BTR*. 2007;90:294-301.
4. Guyatt GH, Sackett DL, Cook DJ. Users' guides to the medical literature. II. How to use an article about therapy or prevention. A. Are the results of the study valid? Evidence-Based Medicine Working Group. *JAMA*. 1993;270:2598-601.
5. Oxman AD, Sackett DL, Guyatt GH. Users' guides to the medical literature. I. How to get started. The Evidence-Based Medicine Working Group. *JAMA*. 1993;270:2093-5.
6. Sackett DL, Rosenberg WM, Gray JA, Haynes RB, Richardson WS. Evidence based medicine: what it is and what it isn't. *BMJ*. 1996;312:71-2.
7. Amis ES, Butler PF, Applegate KE, Birnbaum SB, Brateman LF, Hezezi JM, et al. American College of Radiology white paper on radiation dose in medicine. *J Am Coll Radiol*. 2007;4:272-84.
8. Tigges S, Roberts DL, Vydareny KH, Schulman DA. Routine chest radiography in a primary care setting. *Radiology*. 2004;233:575-8.
9. Brody AS, Frush DP, Huda W, Brent RL. American Academy of Pediatrics Section on Radiology. Radiation risk to children from computed tomography. *Pediatrics*. 2007;120:677-82.
10. Brenner D, Elliston C, Hall E, Berdon W. Estimated risks of radiation-induced fatal cancer from pediatric CT. *AJR Am J Roentgenol*. 2001;176:289-96.
11. Frush DP, Donnelly LF, Rosen NS. Computed tomography and radiation risks: what pediatric health care providers should know. *Pediatrics*. 2003;112:951-7.
12. Reed MH. Clinical decision rules in radiology. *Acad Radiol*. 2006;13:562-5.
13. Prasad KN, Cole WC, Haase GM. Radiation protection in humans: extending the concept of as low as reasonably achievable (ALARA) from dose to biological damage. *Br J Radiol*. 2004;77:97-9.
14. Wood BP. What is evidence? *Radiology*. 1999;213:635-7.
15. Medina LS, Blackmore CC. Principles of evidence-based imaging. In: Medina LS, Blackmore CC, editors. Evidence-based imaging. Optimizing imaging in patient care. USA: Springer; 2006. p. 1-3.

16. Hollingworth W, Jarvik JG. Technology assessment in radiology: putting the evidence in evidence-based radiology. *Radiology*. 2007;244:31–8.
17. Harbour R, Miller J. A new system for grading recommendations in evidence based guidelines. *BMJ*. 2001;323:334–6.
18. Condés E. Biostatistics: a fundamental tool for the elaboration of radiological articles. *Radiología*. 2008;50:265–70.
19. Pita Fernández S. Epidemiología. Conceptos básicos. In: Pita Fernández S, editor. *Tratado de Epidemiología Clínica*. Madrid: Dupont Pharma S.A.; 1995. p. 25–47.
20. Rosenbaum PR. Observational study. In: Everitt BS, Howell DC, editors. *Encyclopedia of statistics in behavioral science*. Chichester: John Wiley and Sons; 2005. p. 1451–62.
21. Pertegaz Díaz S, Pita Fernández S. Revisiones Sistemáticas y Metaanálisis. *Cad Aten Primaria*. 2005;12:109–12.
22. Blackmore CC, Black WC, Jarvik JG, Langlotz CP. A critical synopsis of the diagnostic and screening radiology outcomes literature. *Acad Radiol*. 1999;6 Suppl. 1:58–18.
23. Sheehan JJ, Ridge CA, Ward EV, Duppl GJ, Skahan CD, Skehan SJ, et al. The process of evidence-based practice in radiology: an introduction. *Acad Radiol*. 2007;14:385–8.
24. Zou KH, Fielding JR, Ondategui-Parra S. What is evidence-based medicine? *Acad Radiol*. 2004;11:127–33.
25. Busel D, Silva C. Radiología basada en la evidencia: Estrategia conceptual focalizada para la práctica de la imaginología. *Rev Chil Radiol*. 2004;10:109–17.
26. Kelly AM. Evidence-based radiology: step 1-ask. *Semin Roentgenol*. 2009;44:140–6.
27. Staunton M. Evidence-based radiology: steps 1 and 2-asking answerable questions and searching for evidence. *Radiology*. 2007;242:23–31.
28. Dixon AK. Evidence-based diagnostic radiology. *Lancet*. 1997;350:509–12.
29. Haynes RB. Of studies, syntheses, synopses, and systems: the «4S» evolution of services for finding current best evidence. *ACP J Club*. 2001;134:A11–13.
30. Haynes RB. Of studies, syntheses, synopses, summaries and systems: the «5S» evolution of information services for evidence-based healthcare decisions. *Evid Based Med*. 2006;11:162–4.
31. Dicenso A, Bayley L, Haynes RB. ACP Journal Club. Editorial. Accessing pre-appraised evidence: fine-tuning the 5S model into a 6S model. *Ann Intern Med*. 2009;151. JC3-2, JC3-3.
32. Tan K, Dear PR, Newell SJ. Clinical decision support systems for neonatal care. *Cochrane Database Syst Rev*. 2005;2. CD004211.
33. Fitzmaurice DA, Hobbs FD, Murria ET, Bradley CP, Holder R. Evaluation of computerized decision support for oral anticoagulation management based in primary care. *Br J Gen Pract*. 1996;46:533–5.
34. Solberg LI, Wei F, Butler JC, Palattao KJ, Vinz CA, Marshall MA. Effects of electronic decision support on high-tech diagnostic imaging orders and patients. *Am J Manag Care*. 2010;16:102–6.
35. Evidence Web Site. Available from: <http://clinicalevidence.bmj.com/ceweb/index.jsp> [updated 2007 May 23; updated 2010 Oct 23; accessed 2010 Nov 2].
36. Up To Date Web Site. Available from: <http://www.uptodate.com/home/index.html> [accessed 2010 Nov 2].
37. National Guidelines Clearinghouse Web Site. Available from: <http://www.guideline.gov/index.aspx> [updated 2010 Oct 21; accessed 2010 Nov 2].
38. ACP Journal Club Web Site. Available from: <http://www.acpjc.org/> [published 1991 May 1; updated 2010 Oct 19; accessed 2010 Nov 2].
39. Evidence-Based Medicine Web Site. Available from: <http://ebm.bmj.com/> [published 2000 Jan 1; updated 2010 Oct 1; accessed 2010 Nov 2].
40. Center of Reviews and Dissemination, University of York Web Site. Available from: <http://www.york.ac.uk/inst/crd/> [published 1994 Feb 1; updated 2010 Oct 27; accessed 2010 Nov 2].
41. Center of Reviews and Dissemination, University of York Web Site. Database of Reviews of Effects (DARE). Available from: <http://www.crd.york.ac.uk/crdweb/Home.aspx> [published 1994 Feb 1; updated 2010 Oct 27; accessed 2010 Nov 2].
42. Evidence Updates Web Site [www.crd.york.ac.uk/crdweb/Home.aspx?DB=DARE&SessionID=&SearchID=&E=0&D=0&H=0&SearchFor='DB=DARE&SessionID=&SearchID=&E=0&D=0&H=0&SearchFor=.](http://www.crd.york.ac.uk/crdweb/Home.aspx?DB=DARE&SessionID=&SearchID=&E=0&D=0&H=0&SearchFor='DB=DARE&SessionID=&SearchID=&E=0&D=0&H=0&SearchFor=') Available from: <http://plus.mcmaster.ca/EvidenceUpdates/> [published 2004 Apr 1; updated 2002 Oct 15; accessed 2010 Nov 2].
43. The Cochrane Library Web Site. Available from: <http://www.cochrane.org/> [published 1993 Jan 1; updated 2010 Oct 22; accessed 2010 Nov 2].
44. US National Library of Medicine National Institutes of Health Web Site. Available from: <http://www.ncbi.nlm.nih.gov/pubmed> [updated 2010 Nov 12; accessed 2010 Nov 14].
45. Cabello JB. Plantilla para ayudar a entender un Estudio de Diagnóstico. In: *Guías CASPe de Lectura Crítica de la Literatura Médica*. Alicante: CASPe; 2005. Cuaderno I. p. 22–5.
46. Blackmore CC. Critically assessing the radiology literature. *Acad Radiol*. 2004;11:134–40.
47. Dodd JD, MacEaney PM, Malone DE. Evidence-based radiology: how to quickly assess the validity and strength of publications in the diagnostic radiology literature. *Eur Radiol*. 2004;14:915–22.
48. Cronin P. Evidence-based radiology: step 4-apply. *Semin Roentgenol*. 2009;44:180–1.
49. Cronin P. Evidence-based radiology: step 5-evaluate. *Semin Roentgenol*. 2009;44:182–3.
50. Medina LS, Applegate KE, Blackmore CC. Evidence-based imaging in pediatrics. Optimizing imaging in pediatric patient care. EE. UU.: Springer; 2010.
51. Sardaneli F, Di Leo G. Biostatistics for radiologist: planning, performing and writing a radiologic study. Italia: Springer-Verlag; 2008.
52. Ottenheijm RP, Jansen MJ, Staal JB, Van den Bruel A, Weijers RE, De Brie RA, et al. Accuracy of diagnostic ultrasound in patients with suspected subacromial disorders: a systematic review and meta-analysis. *Arch Phys Med Rehabil*. 2010;91:1616–25.
53. Bipat S, Glas AS, Van der Velden J, Zwinderman AH, Bossuyt PM, Stoker J. Computed tomography and magnetic resonance imaging in staging of uterine cervical carcinoma: a systematic review. *Gynecol Oncol*. 2003;91:59–66.
54. Bipat S, Glas AS, Slors FJ, Zwinderman AH, Bossuyt PM, Stoker J. Rectal cancer: local staging and assessment of lymph node involvement with endoluminal US. CT and MR imaging—a meta-analysis. *Radiology*. 2004;232:773–83.
55. Vanhoenacker PK, Heijnenbroek-Kal MH, Van Heste R, Decramer I, Van Hoe LR, Wijns W, et al. Diagnostic performance of multidetector CT angiography for assessment of coronary artery disease: meta-analysis. *Radiology*. 2007;244:419–28.
56. Staunton M, Malone DE. Can acute mesenteric ischemia be ruled out using computed tomography? Critically appraised topic. *Can Assoc Radiol J*. 2005;56:9–12.
57. Staunton M, Malone DE. Can diagnostic imaging reliably predict the need for small bowel obstruction? Critically appraised topic. *Can Assoc Radiol J*. 2005;56:79–81.
58. Kelly AM, Fessell D. Ultrasound compared with magnetic resonance imaging for the diagnosis of rotator cuff tears: a critically appraised topic. *Semin Roentgenol*. 2009;44:196–200.
59. Ryan JM. Coronary CT angiography for coronary stenosis: a critically appraised topic. *Semin Roentgenol*. 2009;44:188–90.
60. Ryan ER, Heaslip IS. Magnetic resonance enteroclysis compared with conventional enteroclysis and computed tomography

- enterocolysis: a critically appraised topic. *Abdom Imaging*. 2008;33:34–7.
61. Shine S. Urinary calculus: IVU vs. CT renal stone? A critically appraised topic. *Abdom Imaging*. 2008;33:41–3.
 62. Malone DE, McEneaney PM, Schranz M, Skehan SJ, Staunton M. Available from: <http://www.evidencebasedradiology.net> [published 2004 Feb 4; Puerto Fernández M, Santos del Río MJ, Márquez Fernández R. Available from: <http://www.radiologiaevidencia.org> [created 2010 Jan 17].
 64. The Radiology Alliance for Health Services Research Web Site. Available from: <http://www.aur.org/> [published 2002; accessed 2011 Jan 24].
 65. American College of Radiology Web Site Publicado, 2004. Available from: <http://www.acr.org/MainMenuCategories/about.us.aspx> [updated 2010 Oct 14; accessed 2011 Nov 4].
 66. Blackmore CC, Medina LS. Evidence-based radiology and the ACR Appropriateness Criteria. *J Am Coll Radiol*. 2006;3:505–9.
 67. ACR Appropriateness Criteria. Available from: http://www.acr.org/SecondaryMainMenuCategories/quality_safety/app_criteria.aspx [published 2004; updated 2011 Jan; accessed 2011 Feb 4].
 68. Bautista AB, Burgos A, Nickel BJ, Yoon JJ, Tilara AA, Amorosa JK. Do clinicians use the American College of Radiology Appropriateness criteria in the management of their patients? *AJR*. 2009;192:1581–5.
 69. European Institute for Biomedical Imaging Research (EIBIR) Web Site. Available from: <http://www.eibir.org> [published 2009 Feb 1; updated 2009 Oct 16; accessed 2011 Jan 24].
 70. European Society of Gastrointestinal and Abdominal Radiologist Web Site. Available from: <http://www.esgar.org> [accessed 2011 Jan 24].
 71. Sardanelli F, Hunink MG, Gilbert FJ, Di Leo G, Krestin GP. Evidence-based radiology: why and how? *Eur Radiol*. 2010;20:1–15.
 72. Kahan JP, Van het Loo M. Defining appropriate health care. *Eurohealth*. 1999;5:16–8.
 73. Martínez-Sahuquillo ME, Echevarría Ruiz de Vargas MC. Métodos de consenso. Uso adecuado de la evidencia en la toma de decisiones. Método RAND/UCLA. *Rehabilitación*. 2001;35:388–92.
 74. González N, Quintana JM, Lacalle JR, Chic S, Maroto D. Evaluación del uso apropiado de procedimientos sanitarios mediante el método RAND: revisión de su aplicación en la literatura biomédica (1999–2004). *Gac Sanit*. 2009;23:232–7.
 75. Terraz O, Wietlisbach V, Jeannot JG, Burnand B, Froehlich F, Gonvers JJ, et al. The EPAGE Internet guideline as a decision support tool for determining the appropriateness of colonoscopy. *Digestion*. 2005;71:72–7.
 76. Valder JP, Burnand B, Froehlich F, Dubois RW, Bochud M, Gonvers JJ. The European Panel on Appropriateness of Gastrointestinal Endoscopy (EPAGE) project and methods. *Endoscopy*. 1999;31:572–8.