A tool for change in medical practice: "Evidence-based Medicine"

António Vaz Carneiro*

Abstract

Evidence-based medicine (EBM) combines the expertise of the individual clinician with the best external evidence from clinical research into a rational, ethical and effective practice. EBM constitutes a new paradigm for medical practice, in the sense that it tries to transform clinical problems into well formulated clinical questions, selecting and critically appraising the scientific evidence available using predefined strict rigorous criteria. Modern medical practice is an ever-changing process, and the needs of the doctors for information have been partially met by continuing medical education activities, which have been shown not to stop the well-known fact that clinical knowledge, as well as medical practice, deteriorates overtime. The busy clinician has two major problems when faced with the need to get the most recent and relevant information possible: most of the published medical literature is either irrelevant or not useful and he/she has scarce time left for reading it. EBM can be thought and practiced by physicians with different degrees of autonomy, with several subspecialties, working in hospital or in a non-outpatient clinic, alone or in groups.

Keywords: evidence-based medicine, continuing medical education, clinical studies, clinical practice.

Introduction

Medicine has undergone constant changes, the most important of which is, without doubt, the growing need to constantly update the knowledge needed for effective and safe practice. Diagnostic and therapeutic methods are advancing at an accelerated pace, creating problems of self-learning and practical application for those responsible for providing medical assistance to patients admitted to hospitals, observed in clinics or evaluated in emergency services.[1] How can physicians learn the new techniques and master the information in order to introduce changes (where applicable) to the way they practice the art of medicine that in the final analysis, will benefit their patients?

We take the following case as an example: Mr. Silva is a 63-year-old patient recently diagnosed with idiopathic dilated cardiomyopathy (echocardiogram showing an EF of 25%, generalized hypokinesia and dilation of the four cavities); she began therapy with furosemide 40 mg/day and enalapril 5 mg/day. The ionogram and renal function tests were normal two weeks after the start of this therapeutic regimen. One month later, the patient returned to the clinic only with complaints of dyspnea on moderate effort, and normal results in the objective examination (normotensive with signs of jugular vein distension, S_3 or pulmonary rales), except for a very slight malleolar edema. The young intern responsible for this patient, faced with these clinical symptoms, had various doubts and questions as to the best way of effectively and correctly treating this patient with congestive heart failure (CHF).

To start with, and because it seemed to him easier and quicker, he decided to consult a recent edition of a commonly used textbook (Harrison's Principles of Internal Medicine, 14th ed. 1998) which, in the chapter on heart failure, offers six pages about the treatment (pp. 1291 to 1297), including physiopathological concepts, pharmacological details about all the medications that can be used in this context (including those used exclusively in intensive care), details about refractory CHF, heart transplant, and even diastolic heart failure (the latter in just six lines!). Although the author (the renowned Professor E. Braunwald) indicates in the introduction some vague rules about assessing the severity of symptoms and the underlying ventricular dysfunction, it is not possible to conclude, from this reading, as to any formal hierarchy about the drugs to be used, or to identify any

*Internal Medicine Hospital Assistant
Medicine IV Service of the Hospital de Santa Maria, Lisbon
Received for publication on the 4th May 1998

therapeutic subgroup of patients with CHF similar to the patient in question. The reader is merely advised, as first line therapy, to use an angiotensin-converting enzyme inhibitor (ACEI), lisinoprol, in doses of 10 mg/day (without giving the reasons for the choice of this specific drug); if there is no improvement, then the patient's activity and salt consumption should be restricted. If these measures still do not produce a clinical improvement, then diuretics (which?), vasodilatadors (which?) and digitalics should be added, admitting the patient to hospital if the symptoms are still not controlled by these means.

Our intern found that this information did not help resolve Mr. Silva's problem, as it suggested that perhaps the problem was increasing the diuretic dose, together with restriction on the patient's activity and salt consumption, though none of the other suggestions made by the specialist, in his book, can be ignored. It was therefore decided to present the problem to a cardiologist who was visiting a patient on the other side of the corridor: he advised that before altering any aspect of the therapy, the echocardiogram should be repeated to determine the size of the heart cavities, and the degree of systolic or left ventricular dysfunction. Meanwhile, the hospital assistant in Internal Medicine, the intern's supervisor on the ward, was passing by. Presented with the case, he told the intern not to alter the medication and that he should schedule a new appointment for the patient for reevaluation in one month. Presented with three different suggestions on how to improve the patient's treatment, the intern asked himself where he might find information that would serve as the basis for a secure, fast and effective decision.

The young physician – who had the basic computer knowledge necessary to enable him to use a personal computer – then decided to go and look on the Internet for the desired information. After several minutes, he was able to contact the Agency for Health Care Policy and Research of the National Library of Medicine of the USA (http://text.nlm.nih.gov/ftrs/pick?collect=ahcpreftrsK=0t=894153482), a North American state-run agency that is dedicated exclusively to the development of protocols for action based on carefully selected and evaluated scientific evidence. Here he found - among other things - a protocol for action in cases of CHF, in two versions (one complete the other in summarized form), together with information for patients (in English and Spanish!). Checking the recommendations – after printing out the paper – the intern saw that in fact, the first line pharmacology is the use of a diuretic and an ACEi, with subsequent symptomatic and laboratory assessment (which the patient had already had). The next correct step would be to increase the dose of enalapril to 10 mg twice a day, provided the patient remained symptomatic, and there is evidence - in the ATLAS study - that to decrease the mortality and morbidity, the dose of ACEI in CHF should be the maximum dose tolerated. Monitoring of blood pressure and creatinine, and the ionogram, should be carried out in the subsequent two weeks. Although this patient may have improved with an increase in the diuretic dose or the addition of a digitalic, these measures should only be used once levels of ACEI have been reached that are known to improve the prognosis. The best way to monitor the CHF therapy is through the patient's history (tolerated activity before the appearance of symptoms and the factors that precipitate them) and objective examination; sequential measurements of the dimensions and left ventircular function have not proven useful in the decision to alter the therapy in patients with chronic CHF. Now, with updated, well-founded information that was adapted for his specific patient, our intern was able to act with a different reassurance in advising Mr. Silva.

This small clinical example serves to demonstrate two diametrically opposed approaches to obtaining information in Medicine. Traditionally, the sources of knowledge used by the physician include research in the medical literature, consultation with colleagues who have specific competences – so-called specialists,[2] - regular attendance at Professional Development activities (courses, classes or seminars), and even information provided by the pharmaceutical industry, whether directly or through advertisements published in the medical journals.[3] Each of these sources has various degrees of validity, as they each have their particular biases; the problem arises when, as in the case described above, different sources present different suggestions for resolving the same problem.

For the purposes of systematization, we can affirm that a physician's needs for bibliographic information can be revealed in four main contexts: 1) to provide answers to questions and resolve problems that arise during the clinical practice in caring for the patient;[4] 2) the need for continual updating of their knowledge;[1] 3) as support for study and teaching activites:[5]

and 4) as the basis for the construction, implementation and development of clinical or basic investigation projects.[6] Each of these roles that the physician performs create specific needs for information, to be obtained with varying degrees of urgency and importance, but which is always characterized by research, selection and application of the evidence found in the medical literature.

There are more than 30,000 medical journals worldwide, with each issue being duplicated approximately once every 19 years.[7] This reality leads to the main problem faced by the user of the information: the vast amount of information available. For example, based on the most commonly used database - Medline - today there are around 3 million indexed articles, and it is calculated that this figure represents just 30% of the total medical articles existing worldwide.[8] The question that needs to be asked is not whether there is scientific evidence to answer the clinical questions, but this information can be located and selected in a timely and economic way.

The advance in biomedical sciences is continually generating new evidence, which could alter the way Medicine is practiced; this fact leads to the difficulties experienced by physicians in managing to keep up-to-date and obtain answers to the questions raised during the healthcare practice. As a result, we see an inexorable decrease in biomedical knowledge, with a subsequent deterioration in clinical practice; not only are the usual Continuing Professional Development programs in medicine unable to resolve gaps, but they cannot stop the downward trend of "entropy of clinical information", leaving physicians without proper solutions to resolve the problems indicated.[9]

The answers to these problems include the adoption of principles that constitute a new paradigm of medical practice: "Evidence based medicine" (EBM). In the remainder of this article, we seek to explain in detail some of the most important elements that constitute what would be considered EBM, and its practical implementation, advantages and efficacy.

What is EBM?

"Clinical based medicine" is the conscientious, explicit and careful use of up-to-date scientific evidence in the making of clinical decisions relating to the individual patient.[10]

The practice of EBM includes: individual expertise of the physician – the proficiency and capacity for decision-making and judgment that physicians acquire in clinical practice, and that can be revealed, for example, as an added ability to diagnose diseases, select therapeutic regimens that are adapted to the individual patient with integration of their preference and idiosyncrasies, and in general, a balanced relationship with the other professionals and with the health system; better external scientific evidence – which is evidence that provides important information, normally arising from clinical investigation (but can also come from basic investigation) that is focused on the patient (determination of diagnostic characteristics of tests, the efficacy of therapeutic regimens, or the determination of prognostic factors, for example).

Why can EBM be considered a new paradigm of medical practice?

EBM is a new paradigm in medical practice in the sense that it recognizes the most active, professional and effective use in the medical literature, based on the clinical decision, requiring practical physicians to develop individual skills in researching and selecting articles in computer databases, with subsequent application of formal rules in the validation of these pieces of information.[11]

EBM decreases the importance of intuition and non-systematized clinical experience (such as physiopathological reasoning) as the only bases for clinical practice, underlining the concomitant importance of analysis of the evidence obtained through clinical investigation in decision making in relation to the individual patient. Thus, EBM denies some of the premises on which traditional clinical practice has generally been based, namely: 1) individual clinical experience should constitute the only valid means of maintaining and developing knowledge about (for example) diagnostic tests, efficacy of treatments or establishment of prognoses; although absolutely essential for good medical practice, individual experience should be complemented with information from other sources, for example, well-founded studies published in reputable journals (which constitute information gathered in a systematic and unbiased way, from the experience of other colleagues studying similar diseases); 2) the study of physiopathological principles and basic mechanisms of disease are necessary (but not sufficient) for the establishment of rules of practical action in the clinic; the main rationale behind

TABLE I

Rules for critical evaluation of an article about diagnostic characteristics of tests

Are the results of this study valid?

1. Was the comparison of the new test with the gold standard test done in a blind and independent way?

2. Was the test under study evaluated in an appropriate group of patients (comparable to those found in the day-to-day clinical practice for which the test is destined)?

3. Was the gold standard test used in each individual patient, independent of the result of the test under study?

Are the results of this study important?

Result of the diagnostic test	**Results of the gold standard test**	
	Disease present (+) a + c	Disease absent (-) b + d
Test positive a + b	True positives a	False positives b
Test negative c + d	False negative c	True negatives d

Sensitivity = a/(a+c); specificity = d/(b+d); positive predictive value = a/(a+b); negative predictive value = d/(c+d); precision = (a+d)/(a+b+c+d); pre-test probability (prevalence) = (a+c)/(a+b+c+d); pre-test odds = prevalence/(1 – prevalence); likelihood ratio for a positive result = sensitivity/(1 – specificity); likelihood ratio for a negative result = (1 – sensitivity)/specificity; post-test odds = pre-test odds x likelihood ratio; post-test probability = post-test odds/(post-test odds + 1)

Can the results of the study (evidence) be applied to other patients?

1. Is the test under study reliable, executable, available, and accurate in a determined context?

2. Is it possible to obtain a more or less accurate estimate of pre-test probability of the disease to which the test applies (e.g. through clinical experience, literature research, or clinical judgment)?

3. Do the post-test probabilities alter the treatment or the decision to start it?

4. Will the consequences of the test help my patient?

this approach can sometimes lead us into error: for example, the CAST study[12] was designed and implemented to confirm the practice of the generalized use of antiarrythmic drugs in post-EAM patients, based on physiopathological considerations, postulating that the existence of ventricular extrasystolic activity would signify a poor prognosis, as it would introduce a higher mortality rate in these patients. The study should be halted if increased mortality is detected in the experimental groups (administering antiarrythmic drugs of group I), which would demonstrate that the use of suppressant drugs of ventricular extrasolia in patients following acute myocardial infarction is a dangerous therapy; 3) the combination of knowledge obtained during the medical course and a certain common sense are not sufficient to assess the validity of new tests or treatments; it is necessary to understand certain rules of evidence for a correct interpretation of the literature on etiology, diagnostic means, iatrogenics or therapy. As a result, physicians should personally consult the original biomedical literature on a regular basis, and should be capable of critical evaluation using a set of pre-defined methodological rules.

The facts indicated above constitute a new paradigm of medical practice, and oblige physicians to accept (and learn to live with) the uncertainty of their decisions and to recognize that these decision may have to be taken in the context of a certain lack of knowledge of their true ultimate impact.

What are the requirements for the practice of EBM?

The basic steps in the practice of EBM include 1) formulating the clinical question based on the patient's problem and deciding on the information necessary to resolve it; 2) a literature research to select relevant articles/studies; 3) critical evaluation of this evidence in terms of its validity, importance and practical utility, using a set of pre-defined rules (Tables 1 and

TABLE II

Rules for critical evaluation of an article on therapy or preventative measures

Are the results of this study valid?

1. Was the distribution of the subjects by control and treatment groups randomized? And was this randomization adequate (were the codes unpredictable)?

2. Were all the patients who entered the trial present at its conclusion?

And were they analyzed within the groups so that they were initially distributed?

3. Was there double blinding (subjects and investigators)?

4. Were the subjects treated the same in the two groups (except for the trial treatment)?

5. Did the two groups have similar characteristics at the start of the trial?

Are the results of this trial important?

Event/final result		Total
Yes	No	
Control group a	b	a + b
Experimental c	d	c + d

Control event rate: CER = a/(a + b); experimental event rate: EER = c/(c + d); relative risk reduction: RRR = (CER – EER)/CER; absolute risk reduction: ARR = CER – EER; number needed to treat: NNT = 1/ARR

Can the results of the study (evidence) be applied to other patients?

1. Can the results be applied to my individual patient (is my patient so different from those included in the trial that the results will not be applicable to him/her)? What is the scope of the therapeutic effect in my patient?

2. Does the therapeutic/preventative intervention respect the individual desires of my patient (am I aware of them, and am I satisfied with this intervention and its potential consequences)?

2); 4) synthesis, comprehension and presentation of the conclusions of the studies; and 5) practical implementation of the evidence. These performances – collective designed by critical evaluation – are not normally included in the learning, whether pre- or postgradauate, and specific training is needed for its routine implementation.

Knowledge of physiopathology and the basic mechanisms of disease are absolutely necessary for the interpretation and practical application of the results of the clinical investigation. From this point of view, MBE is not much different from traditional medical practice: for example, the practical application of the results of clinical trials in the individual patient requires physiopathological knowledge that enables decision-making on the similarity between that one and those included in the studies (is my patient so different from those of the sample – by age, severity of disease, accompanying pathologies - that he/she would not have been included?).

Another important aspect in the practice of EBM is including patients' preferences and desires in the treatment regimens (whether diagnostic or therapeutic). Acquiring the communication skills necessary for a positive result in this area can be achieved by direct observation of patients, or by working "on the ground" at experienced and exemplary clinics. The need to implement a method of systematic observation in this field will require the use of techniques of behavioral sciences (in the form of randomized trials) as a more effective method of learning these skills.

What are the advantages of EBM?

The practice of EBM brings advantages for individual physicians, heath institutions, universities, and patients and society in general.[13]

EBM enables individual physicians to update their knowledge in a regular, systematic way, improving

their reading habits and their computer information searching skills. These physicians have a better understanding of the methods of clinical investigation and make better use of the data provided by the literature. Also, the practice of EBM increases the physician's confidence in his decisions, and reduces the variation that is so common in clinical practice.[14,15]

For the health institutions, EBM is a tool for improving the quality of services, and enables the construction of management systems that include clinical and financial data, with the advantage that accurate analytical measurements can be established based on these.

For medical schools that have research programs, EBM simplifies the process of synthesis of knowledge that habitually serves as the basis for research protocols, also helping build priorities of investigation for these institutions. EBM is also a powerful tool in pre-graduate teaching, showing students the need for rigorous evaluation of the information, and how to delimit the essential contents to be included in their study.[16]

For the patient, EBM enables more effective communication with the doctor, whether on the options available, or on ways of overcoming the problems and barriers in modern medicine when it comes to the consumption of costly or rare resources.

Finally, society in general finds in EBM a tool that enables health institutions to take responsibility, and in terms of the public, enables advances in medical science to be disseminated in a more rigorous way than is done at present, reducing erroneous expectations among citizens as to the possibilities that modern medicine offers.

Is EBM effective?

With EBM constituting a rigorous and scientific approach to practical medicine, it is absolutely necessary to prove its effectiveness and validity. In other words, it is necessary to answer two basic questions that define the success of an approach of this type: Does EBM improve knowledge and clinical practice? What about the final outcomes of patients? Ideally, the answers to these questions should follow the rules established for any other type of clinical trial, but it is unlikely that randomized studies will be implemented that compare traditional practice with the EBM approach. However, there is published evidence that EBM can be taught to students and interns, and that it enables a better updating of medical knowledge.[17,18]

Like all new approaches, EBM naturally has its advantages and disadvantages.[13] The most common advantages are: EBM integrates medical education with clinical practices; it can be learned by professionals with very different basic training; it may be useful for non-medical social strata (consumer groups); it can facilitate uniformity and rationalization of medical acts (through protocols of action for certain situations, for example); and it can help health administrators to evaluate the effectiveness of the treatments and services it offers to populations. Naturally, EBM also has some disadvantages: it is slow and complex to learn; its practice can be burdensome; it easily exposes "holes" in medical knowledge (causing practical potential problems for physicians who are not used to questioning their own actions); and it requires a knowledge of computer searching methods using databases (which are often not exhaustive).

Conclusions

EBM is a combination between the individual expertise of the doctor and the evidence that comes from scientific investigation, enabling a rational, effective and ethical clinical practice. It is a new paradigm of medical practice in that it transforms clinical problems into questions that can be resolved, and selects and evaluates the scientific evidence, using very restricted and rigorous criteria and rules of evaluation. EBM responds to the changes that have been seen in the practice of modern medicine - characterized by an enormous amount of information that is often irrelevant and useless, combined with a lack of time for reading, updating, and obtaining responses to clinical questions. EBM should be taught and practiced by physicians at various levels of autonomy, in various different specialties, working in hospitals and outpatient departments, whether alone or as part of a group. ■

References

1. Sackett DL, Haynes RB, Guyatt G, Tugwell P. Clinical Epidemiology. 2 ed. Boston: Little, Brown and Company, 1991.

2. Slawson DC, Shaughnessy AF. Obtaining useful information from expert based sources. BMJ 1997; 314: 947-949.

3. Sackett DL, Richardson WS, Rosenberg W, Haynes RB. Evidence-based Medicine. How to practice and teach EBM. 1st ed. New York: Churchill Livingstone, 1997.

4. Covell DG, Uman GC, Manning PR. Information needs in office practice: are they being met? Ann Int Med 1985; 103: 596-599.

5. Williamson JW, German PS, Weiss R, Skinner EA, Bowes FI. Health science information management and continuing medical education of physicians. Ann Int Med 1989; 110: 151-160.

6. Freemantle N, Mason JM, Haines A, Eccles MP. CONSORT: an important step toward evidence-based health care. Ann Int Med 1997; 126: 81-82.

7. Wyatt J. Use and sources of medical knowledge. Lancet 1991; 338: 1368-1373.

8. Greenhalgh T. How to read a paper. The Medline database. BMJ 1997; 315: 180-183.

9. Toon P. Educating doctors, to improve patient care. BMJ 1997; 315: 326.

10. Sackett DL, Rosenberg WMC, Gray JAM, Haynes RB, Richardson WS. Evidence based medicine: what it is and what it isn't. BMJ 1996; 312: 71-72.

11. Evidence-Based Medicine Working Group. Evidence-based medicine. JAMA 1992; 268: 2420-2425.

12. Echt DS, Liebson PR, Mitchell B. Mortality and morbidity in patients receiving encainide, flecainide or placebo: the Cardiac Arrythmia Supression Trial. N Engl J Med 1991; 324: 781-788.

13. Rosenberg W, Donald A. Evidence based medicine: an approach to clinical problem-solving. BMJ 1995; 310: 1122-1126.

14. Blumenthal D. The variation phenomenon in 1994. N. Engl. J. Med. 1994; 331: 1017-1018.

15. Detsky AS. Regional variations in medical care. N Engl J Med 1995; 333: 589-590.

16. Bordley DR, Fagan M, Theige D. Evidence-based medicine: a powerful educational tool for clerkship education. Am J Med 1997; 102: 427-432.

17. Shin JH, Haynes RB, Johnston ME. Effect of problem-based, self-directed undergraduate education on life-long learning Can Med Assoc J 1993; 148: 969-976.

18. Bennett KJ, Sackett DL, Haynes RB, Neufeld VR, Tugwell P, Roberts R. A controlled trial of teaching critical appraisal of the clinical literature to medical students. JAMA 1987; 257: 2451-2454.