FINDING CURRENT BEST EVIDENCE IN THE CARE OF A PATIENT WITH POSSIBLE PULMONARY EMBOLISM: HOW TO USE EVIDENCE RESOURCES

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Mrs. Carter is a 51-year-old woman who presents to the emergency department (ED) complaining of shortness of breath and chest pain. This previously healthy woman was well up until last evening, when she experienced acute pleuritic chest pain. The sensation of difficulty breathing developed shortly thereafter and progressed throughout the night.

Mrs. Carter is evaluated by an ED physician, Dr. Frankel, whose initial assessment reveals mild tachycardia and hypoxemia. After a chest radiograph and an electrocardiogram return normal, Dr. Frankel suspects a pulmonary embolism (PE). He starts the patient on intravenous heparin and sends her for a computed tomography (CT) scan of the chest. At this point he asks you, the senior medical resident on call, to evaluate Mrs. Carter for potential admission upon her return from the radiology department.

While reviewing Mrs. Carter's chart, Dr. Frankel informs you that the CT scan was reported as "negative for pulmonary embolism." He asks whether you still want to see the patient or whether he should send her home. You recall a recent seminar on PE, during which you learned of several controversies in the evaluation of PE with a CT scan. Based on this knowledge, you are uncomfortable sending Mrs. Carter home, and you tell Dr. Frankel you would like to assess her prior to her being discharged.

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Each day we confront a broad range of clinical questions; the answers to which are critical to making optimal patient care decisions. Ideally, we want our clinical decisions to be based on the most up-to-date and reliable evidence—the *current best evidence*. However, a persistent challenge we face in practicing evidence-based medicine (EBM) is a lack of time to acquire, analyze, and apply evidence. Finding the current best evidence can be quick and satisfying or slow and frustrating. The process is dependent on several factors: 1) the *type* of question being asked, 2) *how* the question is being asked, 3) which resources are being used, and 4) the skills for appraising and applying information [1].

While traditional critical appraisal skills remain important for practicing EBM, finding current best evidence in an era of rapidly evolving scientific and medical knowledge also requires skillful and efficient use of available evidence resources. Fortunately, several practical resources are available to support EBM, with new and better tools being developed as a result of expansion in the number of clinically important studies, the range of evidence synthesis and synopsis services, and the capabilities of information technology. Ideally, evidence resources should be created to promote efficiency and to provide medical information according to an explicit and rigorous method that maintains the standards of scientific validity and clinical relevance. If we intend to make EBM an integral part of our patient care, we need to be familiar with available evidence resources and know how they compare in terms of their value for addressing specific questions as they arise in practice.

This article illustrates a basic approach to finding current best evidence and highlights pros and cons of various evidence resources currently available in most institutional settings. Using a case of a patient with possible PE, 6 online resources are consulted in a

quest for current best evidence to address an urgent diagnostic question in the management of the patient. The article departs from the 5-step EBM process typically followed in this series and focuses exclusively on the first 3 steps (assess, ask, acquire), with an emphasis on selecting an appropriate evidence source and designing an effective search strategy.

Assessing the Clinical Problem

From the PE seminar you attended, you recognize the importance of clinical examination findings in determining the pretest probability for PE. Reviewing Mrs. Carter's history, you confirm the onset and characteristics of her symptoms. The patient denies recent immobilization or surgery and reports no personal or family history of thromboembolic disease. In addition, she tells you she has been on hormone replacement therapy for 2 years. She also has a 25 pack-year smoking history and has had normal mammograms and Papanicolaou smears.

Physical examination is remarkable for a heart rate of 110 bpm, a blood pressure of 105/82 mm Hg, and clear lung fields. Her abdomen is benign, and there are no overt signs of lower extremity deep venous thrombosis. You review her normal chest radiograph and electrocardiogram.

Given Mrs. Carter's unexplained pleuritic chest pain, shortness of breath, and tachycardia, you believe that PE is most likely and that alternative diagnoses are less likely. Based on your knowledge of clinical features that predict PE, you estimate her pretest probability for PE is moderate [2]. However, Mrs. Carter reports that she is feeling better, and since her CT scan results are normal, she does not understand why she needs to stay any longer.

Again, you are confronted with deciding whether Mrs. Carter can go home. You realize that your decision hinges on knowing how reliable a negative CT scan is for ruling out PE. Being unsure of this, you explain to the patient that although her CT scan was reported as normal, you need to make sure it is safe to send her home without further testing or treatment. You reassure her that you will get back to her promptly after you have gathered further information and consulted with Dr. Bosch, the attending physician.

You decide the first step in interpreting Mrs. Carter's CT scan is to review it with the radiologist. Fortunately, you find the chest radiologist in the reporting room. You ask if she would read the scan with you and explain what a negative CT means.

Identifying a Patient-Specific Need for Information

As described in the first article in this series, EBM begins with the assessment of the patient problem, our knowledge of the clinical problem, and our learning needs [3]. We must also assess the urgency and importance of the clinical problem and thus the urgency for relevant information.

Mrs. Carter's scenario, not unlike many of the clinical problems confronted daily, raises many questions regarding etiology, diagnosis, and treatment. Paramount to the management of this patient is the determination of the underlying diagnosis and our confidence in that diagnosis. The suspicion of PE is appropriate in this case, given Mrs. Carter's symptoms of unexplained pleuritic chest pain, shortness of breath, and tachycardia and her history of hormone replacement therapy. Unfortunately, the evaluation of PE has always been a diagnostic dilemma. Various diagnostic tests have been assessed for accuracy, but only some have been compared against the invasive gold standard of pulmonary angiography. In addition, a patient with a suspected PE must be assessed and managed promptly, due to the natural history of thromboembolic disease. Hence, the clinical problem becomes determining our confidence in the diagnostic evaluation thus far, as this will establish the next step in this patient's management.

The resident in this scenario clearly appreciates the importance of diagnostic certainty in this case and has appropriately focused on the need to better understand the meaning of a negative CT scan for this patient. This is a common clinical scenario and tracking down a relevant answer will be useful in future practice for this resident, facilitating better management of similar patients.

Asking a Focused Question

The radiologist reviews Mrs. Carter's CT scans with you and explains that the CT used in the evaluation of a PE uses intravenous contrast and produces high-resolution images; this form of CT is referred to as *contrast-enhanced helical* or *spiral CT*. A negative scan indicates the absence of filling defects within the proximal pulmonary vessels. The radiologist also reiterates the excellent specificity of these CT scans for diagnosing PE but notes their variable ability to rule out a PE, given the varying sensitivity of the test. As a result, only a pulmonary angiogram can definitively rule out a PE.

You thank the radiologist for her time and start to focus on the issues that will help you determine the

next step in Mrs. Carter's management, including the pretest probability for PE in a patient like her and the accuracy of a negative CT scan in ruling out PE. You realize you need to review the medical literature to guide your interpretation of a negative CT scan in light of Mrs. Carter's clinical examination findings.

Once we have identified a patient-specific need for information, the next step is to develop a focused, answerable clinical question. Although it may be self-evident, it is important to take a few seconds to clearly define the type of question as being one of diagnosis, prognosis, therapy, prevention, etiology, or another type [4]. Understanding the type of question can expedite the search process in 2 ways: it can guide the selection of resources (some are focused on specific types of questions such as therapy and prevention, whereas others will also include topics of diagnosis and prognosis), and it can help refine a search strategy within the search engine of a specific evidence resource.

Before consulting evidence resources, we need to frame our clinical question using PICO (patient, intervention, comparison, outcome) components to ensure that we obtain answers that apply to the specific diagnostic dilemma in the management of Mrs. Carter. The PICO components in this case may be defined as:

P = patient with moderate pretest probability for PE
I = helical CT
C = pulmonary angiography
O = rule out PE

Using this framework, our focused clinical question becomes:

In **a patient with a moderate pretest probability for PE,** how accurate is a **negative helical CT scan** in **ruling out PE,** compared with **pulmonary angiography?**

Acquiring the Current Best Evidence

As you open the virtual library link on your computer, you are confronted with a list of resources. You select MEDLINE, the resource you are most experienced with, and enter "computed tomography AND pulmonary embolism" in the search box, which results in an overwhelming 1456 citations. You decide to narrow the search to include only articles examining high-resolution CTs, which you just learned are called helical or spiral CTs. You verify the appropriate MeSH term and search on "tomography, spiral computed AND pulmonary embolism." This results in 146 hits. Time is running out, and you need to meet with Dr. Bosch to review Mrs. Carter's case. You print the citations and hope Dr. Bosch can help you sort through all the titles.

You review Mrs. Carter's case with Dr. Bosch and the clinical teaching team and outline the diagnostic dilemma. You feel it is important to trust the accuracy of a negative CT scan in this case, but you are bewildered by how to find an answer to your question in such a short time. You show Dr. Bosch the initial list of MEDLINE citations and ask for her guidance on what to do next.

Dr. Bosch challenges the team to find the best answer to your clinical question using evidence resources available through the hospital's virtual library. She assigns each member a different resource and says to reconvene in 20 minutes. Dr. Bosch emphasizes that when time is short and the stakes are potentially high, it is important to know which resources are most likely to provide current best evidence to answer your question, and to consult them first (**Figure 1**). By having team members share the results from their individual searches, the group can assess the pros and cons of each evidence resource for answering the diagnosis question in this case.

The 3 medical students are assigned Evidence-Based On-Call (EBOC), *Clinical Evidence*, and *UpToDate*, respectively. One intern is assigned *ACP Journal Club* and the other the Cochrane Database of Systematic Reviews. You are assigned PubMed and instructed to search again for relevant original studies, this time narrowing your search using the Clinical Queries feature.

Selecting an Evidence Resource

Having developed our focused question, we now turn our attention to selecting an appropriate resource to search for current best evidence. Many evidence-based information resources have been developed over the last decade in attempt to improve the process and feasibility of practicing EBM in everyday clinical settings. These resources vary in their currency, accessibility, ease of use, reliability for answering specific types of questions, and clinical relevancy. A basic factor to keep in mind before choosing a resource is the time available to search and how long it typically takes to retrieve information from specific resources. Beyond this, we need to appreciate the pros and cons of each information source to maximize the efficiency and effectiveness of our search. Each has its own

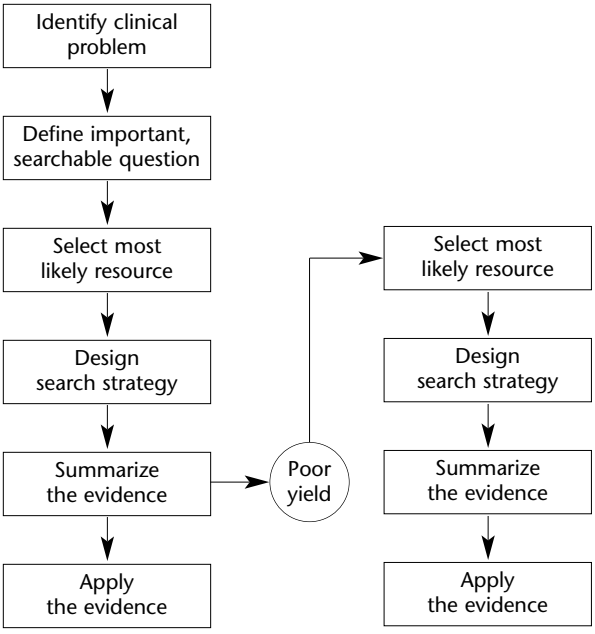

Figure 1. Recommended strategy for finding the current best evidence. To begin, identify the patient-specific need for information and then create an answerable question, recognizing the specific type of question you are asking. The type of question and components of your focused query will help inform the next step, which is to select the accessible resource best suited for your question. (Adapted with permission from Sackett DL, Straus SE, Richardson WS, et al. Evidence-based medicine: how to practice and teach EBM. 2nd ed. London: Churchill Livingston; 2000:41.)

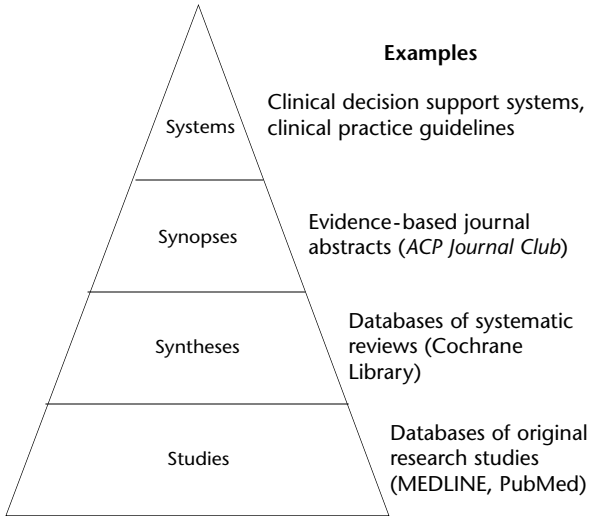

Figure 2. The "4S" levels of organization of evidence from research. At the base of the pyramid are original *studies* on the clinical topic of interest. The next level consists of *syntheses* (systematic reviews) of all available studies on the topic, followed by *synopses* (summaries of individual studies or systematic reviews). Finally, at the top of the pyramid are evidence-based information *systems* (summaries linking several synopses related to a specific clinical problem or type of patient). (Adapted with permission from Haynes RB. Of studies, syntheses, synopses, and systems: the "4S" evolution of services for finding current best evidence [editorial]. ACP J Club 2001 Mar-Apr;134:A11.)

strengths and weaknesses and serves a specific role in the search process.

The "4S" hierarchical classification of evidence resources, first described by Haynes in 2001, can be used to help guide us in selecting from among available evidence resources (**Figure 2**) [5]. It is important to note that this pyramidal organization is not intended to imply superiority of one type of resource over the other; it simply reflects the method by which the evidence is compiled and presented. To improve efficiency and yield of the best current evidence, it is suggested that we begin our search at the highest-level resource available for a problem and work down the pyramid as needed. Resources from the top 3 levels reflect varying degrees of *prefiltering* by experts. These resources save valuable time because the information selected for inclusion has been prescreened for epidemiologic validity and clinical importance.

Systems of Evidence

The medical student assigned to EBOC finds the resource easy to navigate. Browsing the list of clinical "Guides" on the home page, she quickly identifies "Pulmonary embolism" and clicks to open a list of links to evidence summaries relevant to PE. Clicking on the '"Investigations" link opens a page addressing various diagnostic modalities. At the bottom of the page, "helical CT" is listed under the heading "other tests that may be helpful." Clicking on the "+" icon links to a table (**Figure 3**) summarizing the findings from a 2001 study by Perrier et al [6]. Clicking further on the "CAT" icon links to a summary of the study. The descriptive title, "Pulmonary embolism: helical CT can diagnose but not safely exclude it in moderate risk patients," provides a quick answer to the clinical question pertaining to Mrs. Carter. In addition, the summary outlines the patient population assessed, the exclusion criteria, and the independent double-blinded reference standard comparisons. The medical student is alarmed by the fact that the CAT had expired in May 2004 and was last updated in 2002!

The medical student assigned to *UpToDate* similarly finds this resource easy and efficient to use. From the home page, a search on "pulmonary

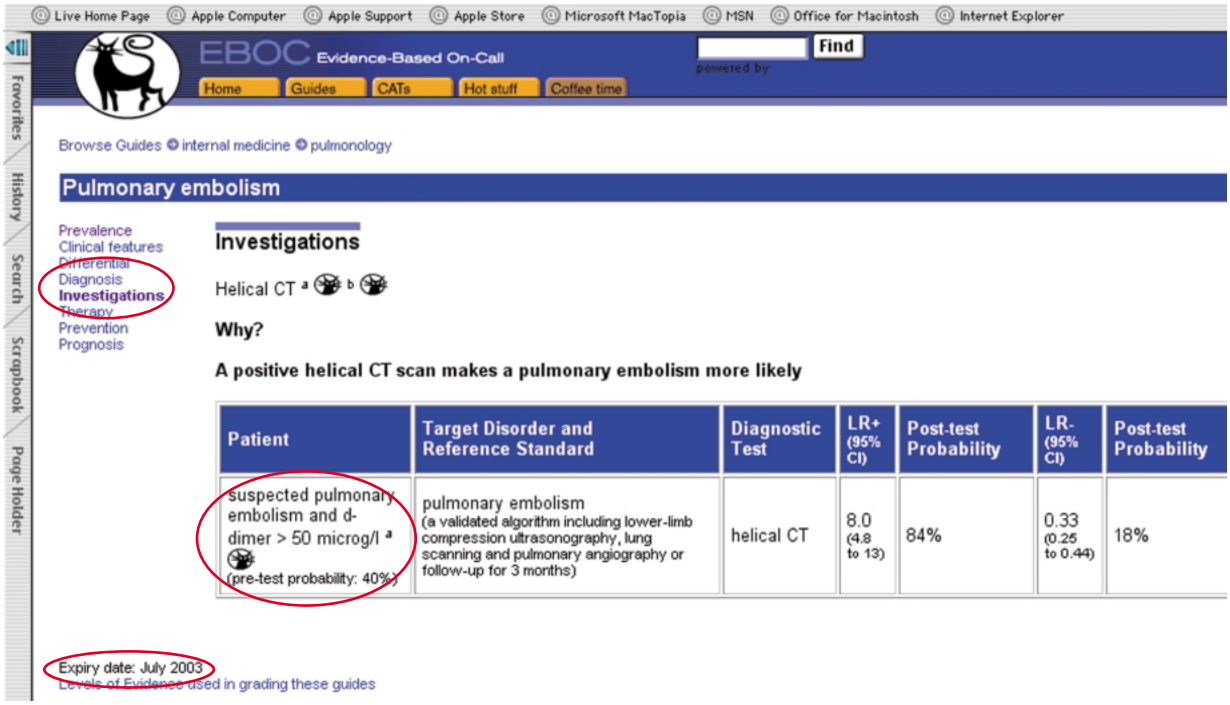

Figure 3. Evidence summary pertaining to use of helical computed tomography for diagnosis of pulmonary embolism, from Evidence-Based On-Call. (Reproduced with permission from the Oxford EBM Group.)

embolism" produces a list of topics that are easily scanned. Clicking on the topic "Clinical manifestations of and diagnostic strategies for acute pulmonary embolism" opens a review on the topic, which was last updated September 2004 [7]. On the left margin of the page, "Helical CT" is listed as a subtopic under "Diagnostic Evaluation." Clicking on this subtopic links to the body of the text where results of various studies of helical CT are discussed. The general sense of the data provided is that there is insufficient information to use helical CT to conclusively rule out a PE, particularly in a patient with a high clinical probability.

The medical student assigned to *Clinical Evidence* begins by entering a search on the home page using the terms "pulmonary embolism AND diagnosis." Zero results return. Searching "pulmonary embolism" produces several pages of results, some unrelated to PE. Skimming the results, the student notices a focus on treatment, not diagnosis. She wonders why Dr. Bosch recommended this resource.

In an ideal world, current, relevant evidence would be available in concise and highly useable formats at the exact time we need it to inform our patient care decisions. Computerized decision support systems that are linked with electronic medical record systems have the potential to be such highly functioning evidence-based clinical information systems. Unfortunately, few highly developed systems of evidence are currently available for easy clinical use. EBOC and *Clinical Evidence* are the closest available resources that approach these ideal information systems, in that they integrate evidence with clinical information and qualify the evidence reported.

EBOC. EBOC is a compendium of evidence-based summaries of clinical conditions that are either commonly seen in the ED, require early effective treatment to avoid serious complications, or typically "confuse or perplex doctors on-call." The site consists of clinical guides and clinically appraised topics (CATs). Two researchers search the literature for relevant articles, specifically targeting *ACP Journal Club*, the Cochrane Library, MEDLINE, and other databases. Articles are selected through a rigorous, multistep process and are then appraised, graded, and summarized, creating a CAT. CATs are used to create the clinical guides. Each clinical guide is divided into sections addressing prevalence, clinical features, differential diagnosis, investigations, therapy, prevention, and prognosis. Bullet point recommendations on diagnosis and management are provided and are linked to

their supporting evidence via the "+" icon, and the grade of evidence is provided. A summary of the articles referred to in the guides is linked via the "CAT" icon. The CAT provides the most relevant information in determining the validity of the study (ie, patient populations, exclusion criteria, study design). Information is presented in bullet points, and results are presented in easy to interpret statistics, such as likelihood ratios (LRs) and number needed to treat or harm. In addition a "clinical bottom line" with the associated grade of evidence headlines each CAT.

EBOC is available online (www.eboncall.org) at no charge and is easy to use. Clinical topics of interest can be sought through a search function or identified by browsing the alphabetical lists of guides or CATS or browsing under the appropriate medical subspecialty (eg, pulmonary medicine for PE). However, EBOC is currently under construction, and various topics have not been updated for more than a year. In fact, the guide consulted for evidence regarding the diagnosis of PE with helical CT was last updated in 2002. It is unclear whether EBOC will continue to be a viable evidence resource in the future, so we must keep this in mind when using it.

Clinical Evidence. The evidence in *Clinical Evidence* is compiled using comprehensive search, retrieval, and appraisal protocols. Topics, formulated as clinical questions related to treatment or prevention (eg, What are the effects of treatments in thromboembolism?), are determined based on reviews of databases of morbidity, mortality, and consultation rates in conjunction with the advice of primary physicians and patient groups. Articles are chosen through a rigorous search protocol targeting the Cochrane Library, MEDLINE, and EMBASE and are appraised using validated methodologic criteria. The evidence is then assembled, summarized, and reviewed by a panel of 3 expert clinicians. Answers to the clinical questions are comprehensively addressed, including specification of the nature and quality of the evidence (eg, systematic review versus randomized controlled trial), the study population characteristics, and whether an intervention was compared with placebo. Therapies are categorized as effective or ineffective and the specific interventions as beneficial or harmful, based on the availability and quality of evidence. Hence, under the topic of PE, questions of therapeutic options are addressed, but there is no discussion regarding diagnostic strategies. Topics are revised every 12 months.

The contents of *Clinical Evidence* can be browsed using the topic's specialty grouping (eg, thromboembolic disease is found under "Cardiovascular"). Once the appropriate chapter is found, one can quickly scan the clinical questions to find the answer to one's original query. *Clinical Evidence* also has an easy to use search engine, which will be even more useful as the content of the resource expands.

Clinical Evidence requires a subscription and is available online (www.clinicalevidence.com), in print form, on CD (also for personal digital assistant), and electronically through Ovid's EBM Reviews (EBMR) service. Currently *Clinical Evidence* is working on diagnostic topics, which are targeted to appear online in 2006.

UpToDate. *UpToDate* is a popular electronic textbook with a broad breadth of content relevant to internal medicine and its respective subspecialties. Unlike EBOC and *Clinical Evidence, UpToDate* does not meet the necessary criteria to be considered a system of evidence, as there are no explicit methods for searching and appraising the evidence. However, the organizational structure and search engine of this resource make it easy to use. Hence, *UpToDate* is one of the most frequently used resources by trainees and clinicians. A search is initiated by entering the topic of interest into the search box. This results in a list of related subtopics organized in the form of electronic chapters. Clicking on a chapter title opens the electronic document. The date of the last update appears at the beginning of the chapter, and an outline of chapter headings appears in the left margin. Clicking on any heading facilitates a rapid link to the corresponding section of the text.

Although *UpToDate* is updated regularly, there can be a considerable delay between the publication of the original studies and the appearance in this resource. Thus, it may not be as reliable for finding the current best evidence for topics in fields where the literature is developing rapidly. Fortunately, *UpToDate* provides MEDLINE abstracts for key evidence, facilitating the user's appraisal of original research studies supporting the authors' claims. *UpToDate* requires a subscription and is available online (www.uptodate.com) and on CD (for PC or personal digital assistant).

Synopses and Syntheses of Evidence

The intern assigned to *ACP Journal Club* opens the link to this online resource, enters "pulmonary embolism AND spiral CT" in the search box, and selects "diagnosis" as the article type. Four matches return. The most recent synopsis is of the 2001 study by Perrier et al [6], and the declarative title states "Helical computed tomographic results indicated small-to-moderate changes in the probability of

pulmonary embolism." Clicking on the title links to a 1-page abstract and a commentary on the study [8]. A thorough summary of the article is provided, with a table showing LRs for positive and negative CT results (positive LR, 8.3; negative LR, 0.34). The expert commentary takes only a few minutes to read and substantiates the declarative title.

The other intern opens a link to the Cochrane Collaboration Web site, enters "pulmonary embolism AND spiral CT" in the search box, and selects to search the entire site (rather than "reviews"). Zero results return. Searching "pulmonary embolism AND helical CT" produces the same result, as does a search using "pulmonary embolism AND CT." A final attempt using "pulmonary embolism AND diagnosis" as the search terms produces 5 results, none of which addresses the use of CT. Frustrated, the intern wonders why such a well-known database has no information on this common diagnostic dilemma.

If a system of evidence is unavailable to address our clinical question, we must look to the next level in the pyramid of evidence resources—databases of synopses of evidence (eg, evidence-based journal abstracts). An example of this type of EBM resource is the popular *ACP Journal Club*. If a synopsis falls short in providing the details we need or is unavailable, the next level of evidence resources is syntheses (eg, systematic reviews). Authors of well-done systematic reviews follow rigorous methods to collect, appraise, and summarize all relevant research studies for a focused clinical question. The Cochrane Database of Systematic Reviews is a prime example of a synthesis type of EBM resource.

ACP Journal Club. Via explicit criteria, the *ACP Journal Club* selects original research studies that are deemed to provide important advances in the treatment, prevention, diagnosis, cause, prognosis, and economics of disorders managed by general internists. Selected studies are summarized in concise abstracts, and each abstract is accompanied by a concise commentary by a clinical expert. The commentary provides a clinical context for the study, addresses methodologic problems that affect interpretation, and offers recommendations for clinical application. Searching *ACP Journal Club* is easy. Key words or phrases are entered into the search field, with the option to limit the search by article type. Boolean operators (AND, OR, and NOT) can also be used to improve the yield. However, because search terms are not identifiable under a standardized system (eg, MeSH), the searcher may need to enter a variety of synonyms to maximize or refine a search. *ACP Journal Club* requires a subscription and is available in print, online (www.acpjc.org), and electronically through Ovid's EBMR service.

Cochrane Database of Systematic Reviews. The Cochrane Database of Systematic Reviews is one of several regularly updated evidence databases in the Cochrane Library, which is maintained by the Cochrane Collaboration. The goal of the Cochrane Collaboration is to provide as clear a signal about the effects of a health care intervention as the accumulated evidence will allow. Their explicit scientific reviews are performed using rigorous protocols and are based on exhaustive search and synthesis of the medical literature. To date, Cochrane reviews focus only on preventive or therapeutic interventions, although a group of diagnostic scholars has been formed and several systematic reviews pertaining to diagnosis are currently underway. The search engine is structured like that of *ACP Journal Club*, with the use of search terms and Boolean operators. The Cochrane Library is published quarterly, with each issue containing previously published systematic reviews plus new and updated reviews. Users may browse and search for abstracts of reviews free of charge on the Cochrane Web site (www.cochrane.org). Full-text access to systematic reviews requires a subscription and is available on CD, online through Wiley Interscience (www.thecochranelibrary.com), and electronically through Ovid's EBMR service.

Evidence Resources for Locating Original Studies

You return to PubMed and click on the Clinical Queries link under PubMed Services. You see that you can run 3 different types of searches. You begin with a search by clinical study category. Selecting "diagnosis" under Category and "narrow/specific search" under Scope and entering "pulmonary embolism AND tomography, spiral computed" yields 24 citations. Scanning the results, the first study catches your eye, as it is relevant to your question and was published this month. You click on the citation to read the abstract. This prospective multicenter cohort study by Van Strijen and colleagues [9] involved 627 consecutive patients with clinically suspected PE, of whom 517 were included in the final analysis. Patients with normal perfusion scintigraphy were excluded; remaining patients underwent single-detector spiral CT and ventilation scintigraphy to diagnose PE, with pulmonary angiography performed as the gold standard. The authors reported that spiral CT correctly identified 88 of

128 patients with PE (sensitivity of 69%) and 92 of 109 patients without PE (specificity of 84%); further, the sensitivity of spiral CT was 86% for segmental or larger PE and 21% for subsegmental PE. You decide to download the full-text article, although you realize you will not have time to appraise the study before reporting back to the group.

You have a couple minutes and decide to try a new search, this time using the "find systematic reviews" feature on the Clinical Queries screen. Searching again on "pulmonary embolism AND tomography, spiral computed" retrieves 3 citations. The first is a meta-analysis by Moores et al [10], published 1 month ago. At first glance, the meta-analysis seems to address your topic. However, as you read through the abstract, you quickly realize that the analysis actually addresses patient outcomes of negative CT scans and not specifically the diagnostic accuracy of spiral CTs to rule out a PE. The other 2 citations include a clinical practice guideline and the evaluation of a diagnostic algorithm. You decide to print these for future reading.

You are out of time and need to report your findings to the team. You take the printed articles so you can assess them more closely later.

If our clinical question cannot be answered using a synopsis or synthesis of original research, we need to turn to searchable databases of original research studies (eg, MEDLINE, PubMed). These resources form the base of the 4S evidence pyramid.

MEDLINE. As we have seen in our case, MEDLINE is a comprehensive resource. Maintained by the National Library of Medicine, this database of published studies has citations and abstracts from more than 4000 journals, dating back to 1966. Due to the variety of synonyms for medical terms, a controlled vocabulary (Medical Subject Headings, or MeSH) is used to index articles included in MEDLINE, which provides a consistent way to retrieve information that may use different terms for the same concepts. MeSH is a hierarchical system, in which more specific terms are organized underneath more general terms. In our case, "spiral CT" or "helical CT" can be used as a search term, but we obtain different results. By using the MeSH term, "tomography, spiral computed," we improve the sensitivity and specificity of our search, as both terms are merged under the heading. Thus, before entering a search term into the query box, it is recommended that we first find the MeSH term for the subject of interest by searching the MeSH Database (listed under PubMed Services on the home page). Searches can be refined using Boolean operators and by imposing search limits (publication type, age, gender, date of publication, language, human or animal, or journal subsets). Clicking on the citation title links the user to the abstract and to the full text of an article, if the individual or institution has an electronic subscription.

Updated daily, the number of citations within MEDLINE grows rapidly. As a result, MEDLINE or PubMed (the free online interface for MEDLINE, www.pubmed.gov), is generally not the most efficient EBM resource. The first problem lies in the large number of retrieved articles, as seen in our initial search. Even 146 citations are too many to scan in an effective manner. This makes it difficult to determine which article will best answer our question in a short period of time. The second is that the articles have not been filtered, leaving us to assess the validity of each study. For these reasons, filtered evidence sources (systems, synopses, syntheses) have been developed.

PubMed Clinical Queries. Found on the home page, under PubMed Services, this useful feature allows us to narrow a search of the medical literature to retrieve individual studies or systematic reviews that have been filtered for clinical relevance and high-quality research methods. Searches by "Clinical Study Category" employ validated search strategies (predefined filters) that focus on clinical content for therapy, diagnosis, prognosis, and etiology [11]. These filters are designed to allow us to maximize either the specificity or sensitivity of our search. The "sensitive" search strategy is used to retrieve every article that may be relevant to the question, whereas the "specific" strategy focuses more narrowly on citations aimed at answering the question.

When the validity of original studies is questionable or we do not have enough time to do a primary analysis of an article, we may want to search using the "Find Systematic Reviews" option on the Clinical Queries screen. This feature uses filters to locate articles on the topic of interest that are identified as "systematic reviews, meta-analyses, reviews of clinical trials, guidelines, evidence-based medicine, and consensus development conferences."

Summary of the Evidence Resources Used in this Case

The members of the clinical team reconvene to present their findings. The medical student assigned to EBOC reports that she was able to find and read a CAT that neatly addressed the team's question in 3 minutes. However, she is concerned that the

Table. Characteristics of the Evidence-Based Medicine (EBM) Resources Consulted in the Case of Mrs. Carter

Resource	Types of Clinical Questions Addressed	Strengths	Weaknesses	Time to Search for and Review Evidence
Clinical Evidence	Therapy, prevention	Rigorous EBM process, well-organized, easy to use, NNT to guide interpretation	Limited topics, subscription needed	2 to 5 min
Evidence-Based On-Call	Prevalence, therapy, differential diagnosis, investigations, prognosis, prevention	Rigorous EBM process, well-organized, easy to use, free online access	Limited topics, infrequent topic updates	3 min
ACP Journal Club	Therapy, diagnosis, etiology, prognosis	Rigorous EBM process, easy to use, study summaries with expert commentary	Limited topics, subscription needed	5 min
Cochrane Database of Systematic Reviews	Therapy, prevention	Rigorous EBM process	Time consuming to read	5 to 15 min
PubMed Clinical Queries	Therapy, diagnosis, prognosis, etiology	Up-to-date database, predefined filters improve efficiency of search, free online access	Requires information seeker to assess the study for validity and applicability	Approximately 30 min
UpToDate	Prevalence, therapy, differential diagnosis, investigations, prognosis, prevention	Well-organized, excellent for facts	Subscription needed, EBM process not rigorous	3 min

NNT = number needed to treat.

resource stated that the CAT had expired in May 2004 and was last updated in 2002. The student assigned to *UpToDate* reports that the resource provided a great deal of information on the various modalities for diagnosing PE, including some references from as recent as 2004. The total time to search and review this resource was 3 minutes. The third student reports that although *Clinical Evidence* was organized by topic and was easy to search, there was no information on the diagnosis of PE.

The intern assigned to *ACP Journal Club* reports that she found a concise synopsis of the same study the student read about in EBOC and was able to review a summary of the study results as well as an expert commentary on the evidence. A total of 5 minutes was spent on the search and reading the synopsis. Although the clinical bottom line was clear (ie, a negative helical CT cannot rule out PE in patients at moderate risk), she wonders whether newer evidence might be available that would be useful to the group. The other intern reports that the Cochrane Collaboration was relatively easy to navigate but did not yield any citations addressing the clinical question. He feels fairly sure he exhausted all search strategies.

Finally, you briefly summarize the abstract of the study by Van Strijen et al [9], which you identified in your Clinical Queries search. You tell the group that, unfortunately, you were unable to read and analyze the article given the time limitation. Fortunately, the study findings are consistent with evidence found in EBOC, *ACP Journal Club*, and *UpToDate*.

As the group presents their findings, Dr. Bosch constructs a table summarizing the pros and cons of each resource used (**Table**) and reviews the strategy for finding the best current evidence (*see* Figure 1). You and the rest of the team are impressed by the potential efficiency and power of an evidence search and suggest creating pocket reference guides using Dr. Bosch's table and figure.

In considering all the information collected, the group decides to more closely examine the study by

Perrier et al [6] and the meta-analysis by Van Strijen et al [9] and to schedule a time to meet with Dr. Bosch to discuss these articles. In the meantime, based on a quick review of the evidence obtained, the group decides that, although Mrs. Carter's CT scan did not reveal a PE, given her moderate pretest probability, it is best to continue treating her with heparin until more conclusive tests can be performed.

The team returns to Mrs. Carter's bedside. She is anxious to know why she was having trouble breathing and whether she can go home. With Dr. Bosch standing by, you explain to Mrs. Carter that although her tests have not demonstrated a PE, the information you have gathered suggests that a normal CT is not reliable for ruling out this serious condition in a person with her symptoms. In addition, you explain that given your suspicion of an embolus, the next best step is to continue heparin therapy and to investigate further. Mrs. Carter understands and appreciates your explanation and agrees to be admitted for further tests.

As illustrated in the case of Mrs. Carter, clinical dilemmas often need to be assessed and managed promptly. The resident in this case quickly identified the problem at hand and by recalling the discussion in her PE seminar and seeking further knowledge to fill in the gaps, she was able to develop a focused question. The resident's major barrier was in conceiving a search strategy.

Dr. Bosch's challenge helped the group to explore the available evidence resources and gain a sense of the strengths and weaknesses of each. As highlighted in the Table, identifying the type of question being asked is an essential first step in deciding which resources are potentially useful. Given the question of diagnosis in this case, *Clinical Evidence* and the Cochrane Library would not be useful to search because they currently lack diagnostic information. However, both of these resources are working to fill this gap. Although in this case all of the resources provided the same answer, when time is limited it is best to start at the top of the 4S pyramid. By starting our search with the most prefiltered information, we can be reassured of the quality and validity of the information provided. If the answer is not found in one of these resources, we can go to the next level.

Although EBOC's efficient search engine, ease of use, and free online access make this resource a logical first choice in the EBM process, the lack of recent updates vastly reduces its utility. *UpToDate* is easy to use, efficient, and informative, but the lack of prefiltering limits its validity and requires the user to do more work. Unfortunately, a subscription is also required. The search engine of *ACP Journal Club* is easy to navigate, and the resource is efficient to use. The concise abstracts and expert commentary provide reassurance of the high quality of the presented material and help to put a study and its results into clinical context.

When prefiltered EBM resources fail to satisfactorily answer the question at hand, PubMed Clinical Queries is the next step. Its free online access, ease of use, and rigorous methodology in retrieving clinically relevant and high-quality studies make PubMed Clinical Queries a very useful tool. However, given the fact that articles located through PubMed need to be read and analyzed by the user, the process is substantially longer. If we are not satisfied with the information found in PubMed, a next possible step is the development of a research proposal!

As we sort through the available EBM resources, an important consideration is the validity of the information provided. We should ensure that the resource provides a description of the methods used to seek and appraise evidence. Relevant references should be cited, so we can easily access and verify the validity and reliability of the original research in support of recommendations. We should also ensure that the resource is updated frequently, ideally at least once a year. However, we must realize that even the most up-to-date evidence resources may have a significant lag time from the publication of original studies to their incorporation into the resource. This may pose a problem for medical topics for which there is a significant turnover of literature. On the other hand, the interpretation and analysis of original studies is dependent on our time and skill; hence high-quality, prefiltered resources not only save time but are reassuring in their validity.

Conclusion

The rapidly expanding volume of medical literature makes it challenging for us to keep up-to-date. At the same time, evolving standards of care will require that we are able to effectively access the current best evidence for practice decisions. One approach for the problem of obsolesce of professional education is "learning by inquiry." When confronted by a question for which we are unsure of the current best evidence, we need to develop the habit of efficiently searching for this information, thus developing skills for lifelong learning. The efficiency and success of our

EBM searches is dependent on our ability to develop a focused question and then to navigate through the available resources. By understanding EBM services and how they are developed and by staying well informed about the relative quality, scope, and value of these resources, we can become not only wise EBM consumers but more importantly deliver the best care for our patients.

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How to cite this article:

Rambaldini G, Straus SE. Finding current best evidence in the care of a patient with possible pulmonary embolism: how to use evidence resources. Semin Med Pract 2005;8:1–11. Available at www.turner-white.com.