Evidence-based Medicine:
Searching Literature and Databases for Clinical Evidence (Search Tools)

Gary M. Onady MD, PhD,* Marc A. Raslich, MD*

Computers and Internet Support for an Evidence-based Search

Questions are common in clinical medicine. A report studying the needs of residents for medical information found that two new questions arose for every three patients seen. (1) The answers are available. A study by Covell and associates reported that 83% of questions generated in the office setting had answers available in the medical literature. (2) Unfortunately, these studies also showed that clinicians pursued solutions to only 30% to 35% of the problems, with most coming from print resources immediately available in the office. Textbooks are the traditional resource used currently, but the information contained in them often is obsolete. A recent review confirmed that the most frequent source of information is texts. (3) The next most common resource is talking with a colleague; only one report of 19 included studies revealed electronic databases as the primary resource.

The potential for finding answers in the evidence-based paradigm never has been greater in this era of personal computers and Internet resources. A recent report showed that residents and faculty at a children's hospital frequently pursued answers to clinical problems. (4) After a 10-minute intervention and some guidance in finding efficient Internet resources, the participating physicians were more likely to use electronic resources to answer their questions, which was particularly beneficial because the search took only 8 minutes for the intervention group versus 19 minutes for the control group.

Practicing physicians may not realize the potential for enhancing an evidence-based practice using literature resources. (5) Frequently, we encounter relevant clinical questions for which answers are available by accessing effective resources. Physicians need to learn how to access this information.

Although the primary goal of this article is to provide information for getting started on a search, we also hope to convey the ease of conducting an Internet-based search. (6) These techniques not only can help increase the utility and efficiency of the search, but they may improve clinical practice as well. Klein and colleagues (7) found that inpatients for whom literature searches were conducted early in the course of admissions incurred significantly lower costs, charges, and length of stay compared with patients in which searches were performed later in the admission or not at all.

Basic Steps and Tools Used in Searching the Literature

The EBM Toolbox (Figure) illustrates the available tools for literature searches. This article focuses on tools used to execute a literature search. The key terms that are in the right-hand portion of the research evidence drawer are derived from the answerable question crafted in the first step of the EBM process. (6)(8) Terms in the toolbox can come from words extracted directly from the answerable question or converted to Medical Subject Headings (MeSH) terms used by the National Library of Medicine (NLM) in cataloging research summaries.

The Operators section of the drawer provides tools that fasten terms together and can narrow the search. Table 1 lists the steps involved in conducting a literature search. (9) A case introduced earlier in this series (8) illustrates the application of these concepts:

A 12-year-old boy presents with a 4-day history of a limp associated with fever. Notable findings on the physical examination are a temperature of 102°F (38.5°C), minimal weight bearing, and localized tenderness on palpation of the lateral right thigh and hip. There are no signs of abrasion or soft-tissue infection. The erythrocyte sedimentation rate and white blood cell count are significantly elevated.

*Medicine-Pediatrics Program, Wright State University, Dayton, Ohio.

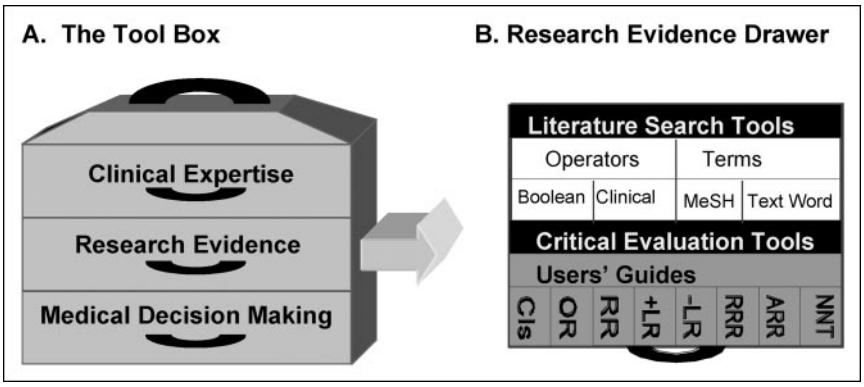

Figure. The EBM toolbox. MeSH=medical subject heading, CIs=confidence intervals, OR=odds ratio, RR=relative risk, LR=likelihood ratio, RRR=relative risk reduction, ARR=absolute risk reduction, NNT=numbers needed to treat

Step 1. Information Sources

The first step in conducting a search for evidence is recognition of convenient and readily available resources. It helps to visualize sources available for a literature search as an information pyramid. (10)(11) Haynes describes this as a "4S" approach to locating current best evidence. (12) This hierarchical information pyramid divides evidence from top to bottom into systems, synopses, syntheses, and studies. Each level contains a greater amount of data than those above it and requires added effort to search through. Clinicians should seek information at the systems level first. If this level is not productive, the search proceeds through synopses, followed by syntheses and finally original studies.

SYSTEMS

An ideal evidence system ensures that the "right provider is doing the right thing for the right patient at the right time in the right setting with the right resources." (13) The development of such a tool is underway through the mechanism of electronic medical record (EMR) systems. EMR systems can integrate evidence into the documentation of a clinical encounter as care is given. They can make this evidence readily available and even remind clinicians of guidelines when they access a particular record. For example, a reminder could alert the clinician to a diagnostic step that is needed to evaluate a particular condition or that a patient has not received a recommended immunization. These systems do not make decisions; rather, they provide timely, relevant information that is a part of any evidence-based clinical practice.

However, most clinicians do not have an EMR system available. In addition, the current systems are not acquired easily, are not necessarily based on sound evidence, and cover only a small number of clinical situations.

Some databases that have the potential for being integrated into an EMR program and could guide clinicians if so incorporated are *UpToDate* (http://www.uptodate.com) and *ACP Medicine*, which is a collaboration between the American College of Physicians and WebMD (http://acpmedicine.com). These are regularly updated, evidence-based textbooks. Unfortunately, they are not always clear in their processing of information and how they include references, and they cannot be integrated into most EMR systems.

Another potential systems reference is *Clinical Evidence*, a question-based, formatted publication that provides critically appraised summaries of the answers to specific therapeutic questions. Included is a section specifically devoted to child health that contains more than 100 pages of pediatric information, with quarterly updates (http://www.evidence.org). Currently, these databases are not available in EMR systems, and clinicians must integrate information from various sources into their own practices.

SYNOPSES

If no evidence-based systems are in place or if they do not address the clinical question, synopses should be the next source in the search. Many people refer to these as secondary sources. These commercial products list titles for each abstract, followed by a synopsis of findings, in some cases providing enough quality information to make a decision. Sample products available online and in print include *American College of Physicians (ACP) Jour-*

Table 1. Steps to Conducting a Literature Search

Step 1. Recognize sources of clinical evidence
Step 2. Select terms that direct the search most efficiently
Step 3. Combine search terms into a logical format
  A. Text/MeSH terms (fastened by)
  B. Boolean operators
Step 4. Adjust search parameters

nal Club, *Evidence-based Medicine*, *American Academy of Pediatrics (AAP) Grand Rounds,* and *Alternative Medicine Research Report.*

Synopses also have been cataloged in the form of critically appraised topics (CATs), typically indexed by systems. The University of Michigan site is useful, providing institutionally produced CATs as well as links to other CAT sites worldwide (http://www.med.umich.edu/pediatrics/ebm/cat.htm).

The primary benefit of synopses is their efficiency in providing critical appraisal of relevant material. These sources sometimes can provide a fast answer. To be most useful, synopses should be explicit in defining their inclusion criteria and how they judge the quality of citations. Fortunately, both resources from the ACP and AAP satisfy these requirements and are reliable. CATs tend to be less explicit in describing their methods. Several pediatric journals now have sections devoted to providing physicians with similar reviews. "Archimedes" in the *Archives of Disease in Childhood* and "Abstracts from the Literature" in *Current Best Evidence (*formerly *The Journal of Pediatrics*) are two such examples.

SYNTHESES

The next resource to tap should be a synthesis, the prime example of which is the Cochrane Library. The Cochrane Library is a commercial resource that provides a collection of systematic reviews of health care interventions, focusing primarily on therapeutics and prevention and providing quarterly updates.

Click at this point on the Cochrane Library hypertext link http://www.cochrane.org/reviews/index.htm. In the search window provided at this site, insert a broad term such as "otitis media." Review the abstracts retrieved in this search. Save the results of the search to compare with one you will complete later with a PubMed link.

A systematic review (evidence synthesis) is based on a rigorous search, explicit inclusion and exclusion of certain data, and systematic compilation of the evidence. Cochrane peer review searches follow this rigorous structure, drawing from sources that include the United States National Library of Medicine (MEDLINE), the European database on *Exerpta Medica* (EMBASE), and hand searches. Various search engines now assist the process by indexing these and other systematic reviews, allowing for easy identification and retrieval. They provide detail about a specific clinical intervention. However, unlike synopses, syntheses can be very technical, making it more difficult to verify and use the findings of the synthesis.

STUDIES

Finally, if other efforts have been fruitless, answers may be found in original studies. For the searcher who is not specifically trained and experienced, this can be an intimidating and timely endeavor. Barriers to finding the right information in a sea of studies include lack of time, isolation, lack of access to a library, technologic illiteracy, lack of equipment, and cost. (14) Examining individual studies is the least efficient resource, and acquiring basic skills to navigate through this information is important.

Several search engines help access titles and abstracts. MEDLINE may be accessed easily through the PubMed search engine that is maintained by the NLM and presents English-language abstracts covering more than 4,300 journals published in more than 70 countries from 1966 to the present (http://www.ncbi.nlm.nih.gov/PubMed/). MEDLINE is only one of a family of 40 databases within the NLM Medical Literature Analysis and Retrieval System (MEDLARS). NLM Gateway is another free entry to the MEDLINE system that has additional access to pre-1966 journal citations called OLDMEDLINE.

Commercial products such as OVID also are available for MEDLINE access and have additional links to high-level information databases such as *Clinical Evidence* (http://www.ovid.com). One search engine attentive to the quality of evidence is SUMSearch (http://sumsearch.uthscsa.edu/searchform45htm).

The next three steps in conducting a literature search examine the process of interacting with databases. Internet access is essential to this process. Table 2 lists some of the more useful information resources available on the Internet that can lead to different types of evidence.

Step 2. Select Terms That Direct the Search Best

Text terms should be chosen that are wide enough to catch a significant number of references and yet search precisely enough to eliminate unnecessary material. These terms are generated by the answerable question, which in this example is, "For a child presenting with a limp, does fever with decreased weight bearing favor septic arthritis over tenosynovitis?" Two types of terms are used when searching the literature: MeSH and text words.

MeSH terms come from the NLM and represent a specialized vocabulary of nearly 20,000 indexed terms, of which 10 to 12 generally characterize a particular article. An additional 300,000 synonyms link an individual's search terms to the appropriate index term.

Text words represent uncontrolled vocabulary that

Table 2. **Internet Informational Resources**

Resource	Location	Information
Search Engine	www.google.com	General patient information, professional organization sites, and a large database of medical images
Professional sites	www.generalpediatrics.com	Incredible database of Web sites specifically for the practicing pediatrician
Guidelines	www.aap.org/policy/paramtoc.html	American Academy of Pediatrics guidelines
	www.guideline.gov	National Guideline Clearinghouse
	www.acep.org/1,18,0.html	American College of Emergency Physicians
	medicine.ucsf.edu/resources/guidelines	Some navigating required
EBM basics	www.med.ualberta.ca/ebm/ebm.htm	
Search engine	www.ncbi.nih.gov/entrez/query.fcgi	PubMed access
CATs	www.med.umich.edu/pediatrics/ebm/cat.htm	Great starting point
	pedsccm.wustl.edu/EBJournal_club.html	Critical care
	www.med.monash.edu.au/healthservices/cce/evidence/	170 evidence reports

provides no guarantee that the chosen term was used by the author within the same context as the answerable question. Text words may be used in a trial search, which allows identification of MeSH terms from relevant abstracts and a repeat search using the MeSH headings. Alternatively, text terms may be "tested" or identified as MeSH headings by checking a convenient link provided by search engines such as PubMed. In the case example, "fever" and "weight bearing" are appropriate primary search terms.

An example using these two search types should help clarify the difference between them. In PubMed's search box (http://www.ncbi.nlm.nih.gov/PubMed/), search for the term "ear ache." This attempt should produce approximately 273 citations. If the more specific phrase "otitis media" is used, nearly 16,000 citations are found, creating a much richer initial database. "Otitis media" is a MeSH heading, but "ear ache" is not.

How do you know if your selected phrase or word is a MeSH phrase? Find now the MeSH heading Tutorial in the left blue window of the PubMed site on the screen under the heading "MeSH Database." Click on the MeSH hypertext at the beginning of the introductory sentence. Continue navigating in the next window by clicking Online searching under the MeSH Browser category. On arriving at this site, enter the term "ear ache" into the search window provided to find MeSH terms that best match the text term chosen initially.

Alternatively, click on the hypertext link provided to proceed directly to the window designated http://www.nlm.nih.gov/mesh/MBrowser.html. There is a searchable database available from the main PubMed home page. This tool not only confirms if your topic is a MeSH term, but it makes suggestions related to your search term if it is not a MeSH term.

(If you are having trouble or would like more information on using PubMed, take the online tutorial, which can be accessed from the PubMed home page via a hypertext link in the left column under "Entrez PubMed" or consult your local medical librarian.)

Step 3. Combine Search Terms into a Logical Format

This step incorporates the search terms into a "search sentence," using operators and sometimes punctuation. Boolean operators provide connections between the search terms; clinical operators define specific areas of interest.

THE BOOLEAN OPERATOR TOOLS

The Boolean operators AND, OR, and NOT help define the content area. The AND function reports only those references containing both connected search terms; OR includes the entire area of references retrieved by both search terms. The NOT operator excludes an identified search term from being reported.

At this juncture, when this article initially was written, the search terms [Limp AND Fever] provided 29 references from a PubMed search, [Limp OR Fever] resulted in 87,697, and [Limp NOT Fever] resulted in 465 references. These numbers change over time. A review of MeSH headings does not identify Limp as an indexing

Table 3. Clinical Operators for Literature Searches

Clinical Domain	Clinical Operator
Reviews	Review Overview
Clinical Manifestations	Diagnosis Complications
Etiology	Relative AND risk case-control
Differential Diagnosis	Differential diagnosis
Diagnosis	Sensitivity Specificity
Therapy/Prevention	Random Clinical trial
Prognosis	Cohort Prognosis Incidence

Combining clinical operators with the OR operator increases the search yield.

term. Weight Bearing is identified as a MeSH term within PubMed.

Repeating the search with [Weight Bearing AND Fever] yields eight references, of which one article (Kocher MS, Zurakowski D, Kasser JR. Differentiating between septic arthritis and transient synovitis of the hip in children: an evidence-based clinical prediction algorithm. *Journal of Bone and Joint Surgery of America*. 1999;81:1662–1670) appears highly relevant. A brief review of the article abstract seems to describe a series of patients similar to ours. Further critical appraisal of this evidence will be described in the next article in this series, where the focus will shift to the front section of the Research Evidence drawer.

THE CLINICAL OPERATOR TOOLS

Clinical operators narrow the search further based on the area of interest. Specific terms can be used to direct a search toward review articles or to focus on the specific areas of clinical manifestations, etiology, differential diagnosis, diagnostic testing, prognosis, therapy, and prevention. (10) Table 3 summarizes terms used for these search strategies. When we added the term "diagnosis" to our search, the repeat search yielded seven articles, including the article by Kocher et al. In this situation, adding the clinical operator was unnecessary because reviewing eight abstracts is manageable. However, using this application illustrates how a search can focus on a desired clinical retrieval within the context of the answerable question. Fortunately, these strategies have been automated for use in PubMed at a special screen designated "Clinical Queries" and found in the left column of the home page under PubMed services. (15)

Step 4. Adjust Parameters of the Search

The "search sentence" usually requires further manipulation to find the most relevant references. Additional limits can be placed on the "search sentence" that consist of the following parameters: 1) time span; 2) age range; 3) language; 4) human versus animal subjects; 5) title or abstract versus full text; and 6) publication type, such as review articles or randomized controlled trials. The more experienced searchers add these terms directly onto the search sentence. However, this takes some practice to do correctly.

PubMed has another, easier method available. Under the search box is a series of links. Choosing "Limits" takes the user to a page that offers the various limiting options. For our search, with the references already limited to seven from the most recent version of the "search sentence," this additional step is not necessary.

Referring to the "otitis media" example illustrates how these limits can save time by providing a more reasonable number of relevant citations to review. As noted earlier, searching "otitis media" yielded a mammoth 16,000 citations. Attempting this search with the limit tool and choosing: 1) English Language, 2) All Children, 3) Meta-Analysis, and 4) From 1990 reduces the number of retrieved articles to 22 citations. The limiting action significantly reduced the number of citations yet still provided a group of relevant articles on otitis media therapy.

Putting It All Together

The four-step literature search applied to the 12-year-old patient resulted in the following outcome. No systems yielded a result that matched the answerable question. Searching at the synopsis level included a CAT bank, but no relevant topics were found under headings for septic arthritis. The Cochrane Library, representing the next tier on the literature pyramid, listed five references for the search terms "Weight Bearing AND Fever AND Diagnosis," but none of the abstracts was pertinent to the answerable question. The final search at the studies level resulted in the single MEDLINE article by Kocher et al, which was the most helpful source of evidence. We were surprised to find when matching our patient's clinical findings with the differential points of transient synovitis versus septic arthritis in the table in that article that our patient has a 99.6% chance of having septic arthritis.

The total time investment was 10 minutes. This effort

represents a reasonably efficient use of time to deliver the best and most current information relevant to this patient's situation. Incorporating this clinical article into medical decision-making requires critical evaluation skills to determine the validity and applicability of the information it contains. The next article in this series addresses these skills.

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