Finding Information by "Design": Search Strategies for Cardiothoracic and Vascular Anesthesia Literature

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CARDIOTHORACIC AND VASCULAR anesthesia is a dynamic field with a strong emphasis on evidence-based care. Efficient literature searching is an indispensable tool for medical practice, research, and education. The practice of evidence-based medicine requires the integration of the best available evidence with patient conditions and preferences to guide clinical practice every day.[1] However, keeping up with the literature has become an increasingly difficult task for the busy practicing physician. The amount of medical information available has increased exponentially. It is estimated that the average physician uses 2 million pieces of information to practice medicine.[2] There are 7 million pages of information added to the World Wide Web every day.[3] "Information overload" is being recognized as a prevalent problem.[4] In 1996, Waddington reported that information overload was leading to stress and tension within the work environment, resulting in longer working hours, loss of job satisfaction, decrease in social life, tiredness and illness, and a degradation in personal relationships.[5] The report underscored the need to take information management seriously. This has led to a growing realization among the medical community of the importance of acquiring and teaching information management skills.

Traditionally, physicians have relied on textbooks, journal articles, and advice from colleagues when faced with a clinical question.[6] However, this may not yield the most accurate or most current information. Reports indicate that general practitioners usually underestimate their information needs.[7] This is probably true of every specialty in medicine. To better manage information, clinicians need to understand the basic concepts underlying the different types of literature, appreciate their strengths, and know how to find the literature that will best meet their needs. A large number of health care professionals also use search engines like Google and Yahoo for information on biomedical literature. Searches in Google Scholar retrieve results that include scholarly literature citations as well as books, abstracts, and material from other scholarly organizations. When using a search engine, using quotes to indicate phrases (eg, "perioperative outcome") and using advanced search options usually yield better results. However, clinicians needs to be aware of the shortcomings of using a search engine for complicated biomedical searches. One of the drawbacks is that relevance ranking is based on characteristics of the Web page and not on an assessment of its meaning (eg, medical subject headings [MeSH] terms). Search engines also are not usually as amenable to complex searches as bibliographic databases.[1]

There are many tools to facilitate the practice of evidence-based medicine including systematic reviews, users' guides to medical literature, strategies to improve quality of literature searches, and online resources to get high-quality information for point-of-care use. These tools are often poorly understood and, thus, improperly used. In addition, residency programs offer inadequate education on the use of these tools. Understanding that some information is freely available whereas other information requires a subscription (personal or institutional) is also an important distinction and may determine which database physicians use to search for information. In this article, the authors describe guidelines for the efficient and effective use of biomedical information tools, strategies to increase the yield of relevant material during literature searches, electronic tools available to the busy practicing anesthesiologist, and a practical solution to integrating information management in the curriculum for medical students and residents as well as for faculty development programs. The methodology behind evidence-based medicine and the process of critically evaluating published literature are beyond the scope of this review and will not be discussed here; they are described very well elsewhere.[1,8-10]

SYSTEMATIC APPROACH TO INFORMATION RETRIEVAL

When faced with a scenario in which more information is needed, it is helpful to follow a systematic, step-by-step approach to get the information desired in the most efficient and effective process.

Step 1

The physician begins by creating a structured, answerable question. It may take some time to actually distill the question into component parts.[10-12] However, it is important to get as specific as possible with the question so that the clinician can get relevant results from the literature search. A good question has 4 essential parts to it, which are best remembered by the following mnemonic PICO.

1. **P**atient population: The patient or the population who has similar attributes to your patient.
2. **I**ntervention (or exposure): What happens or is done to that population. It might be an intervention or an exposure.
3. **C**omparison: A well-defined comparison group that experiences a different intervention/exposure or no intervention/exposure.
4. **O**utcomes: The outcomes (eg, morbidity, mortality, quality of life, cost, and length of hospital stay) that are likely to be most important to patients, policy makers, service providers, or clinicians.

Step 2

Having structured the question, the next step is to identify the type of question. Some common types of questions are as follows:

1. Intervention or therapy: What will be the effect of a particular intervention on the patient?
2. Diagnostic accuracy or differential diagnosis: What is the likelihood that one disease or another is causing the condition? What is the accuracy of a particular diagnostic test?
3. Prognosis: What will be the likely long-term outcome of a particular intervention or therapy?
4. Harm: How might the intervention cause harm?
5. Baseline risk: What is the risk that someone within a particular population will develop a condition?

Step 3

Once the clinician determines the type of question he/she is asking, he/she needs to identify the study design(s) that will best help answer it[8,10] (Table 1). The type of question will determine the type of literature that will yield the desired information. Each type of literature has its own pros and cons:

1. Systematic review: A systematic review uses an explicit and reproducible methodology to identify, appraise, and summarize primary studies. The methodology must state specific objectives, materials, and methods used. Although a systematic review may contain a meta-analysis, a meta-analysis is not always a systematic review. A meta-analysis reviews data from a number of studies and provides a statistical interpretation of whether the intervention is useful or not. A

systematic review is distinct from a meta-analysis because of the stringent methodology (eg, The Cochrane Library).
2. Critically appraised topic (CATs): A critically appraised topic begins with a question. Relevant literature is then retrieved and synthesized. Risks, benefits, and cost for each treatment option are weighed with the available evidence. Multiple critical appraisals may be distilled into larger CATs (eg, CAT Crawler).
3. Randomized clinical trials (RCTs): An RCT is a study of the effect of therapy on real patients. The methodology includes minimization of bias (randomization and blinding) and comparison of defined variables and outcomes between groups (different interventions including no intervention). Limitations are usually associated with methodology problems (eg, ARDSnet trial for low-tidal-volume ventilation).
4. Cohort studies: Cohort studies involve a large population that is followed for a period of time. Patients are grouped by the presence or absence of a particular clinical condition or by having (or not having) received a particular treatment regimen. There is no attempt to stratify other variables, and the 2 groups may be significantly different because of this (eg, Framingham Heart Study).
5. Case-control studies: Case-control studies involve patients with a specific clinical condition who are "matched" with patients who do not have the condition. The matching points include age, sex, associated diseases, and so on. These studies may be prospective or retrospective. Retrospective studies may be confounded by incomplete medical records and patient recall issues. Showing a statistical relationship does not necessarily indicate causation (eg, early studies examining the relation between tobacco smoking and lung cancer).
6. Cross-sectional study: A cross-sectional study observes a defined population at a single point in time or time interval. Exposure and outcome are determined simultaneously. This type of study is used to determine the incidence and prevalence of disease in a particular population.
7. Case reports and case series: Case reports and series are presentations of the treatment of a single patient or small group of patients. There is no statistical validity because there is no group for comparison. These reports can be helpful in identifying a question that should be evaluated and answered. They play an important role in the discovery of new diseases and unexpected side effects of new drugs. They played an important part in the epidemiology of West Nile encephalitis in New York and tracing the spread of the Severe Acute Respiratory Syndrome (SARS) epidemic.
8. Expert opinion: An expert opinion is a summary of findings reflecting current thinking on the topic written by a recognized expert in the field. When using these resources, it is important for clinicians to consider whether the author used a thorough and systematic process to gather information used to formulate their findings, opinions, and recommendations. Not every resource clearly identifies this information (eg, physician-authored infor-

Table 1. The Best Sources To Find Information Regarding Different Types of Questions[8,10]

Question Type	Best Sources
Intervention	RCT and systematic reviews, cohort studies, case-control studies, case series
Diagnosis	RCT
Prognosis	Cohort studies, case-control studies, case series
Harm	RCT, cohort studies, case-control studies, case series
Assessing baseline risk	Cohort or cross-sectional design

mation and advice on conditions and treatments in resources such as UpToDate or eMedicine).

Step 4

The next step is to identify the database or resource that contains the type of literature needed to answer the question. Once the clinician has determined which type of study or literature will help answer their question, they need to understand which resources to use to obtain that type of literature. Most relevant resources for searching the biosciences literature are now available online.

Resources

Although many resources offer reviews, synopses, and studies, most of the topics are directed at clinicians in internal medicine. Following is a list of databases that are useful to the cardiac anesthesiologist. The resources are listed based on the type of literature they index and collect.

The following resources list systematic reviews, CATs, and guidelines (Table 2):

1. Cochrane Database of Systematic Reviews: This resource was created by the Cochrane Collaboration and contains more than 1,300 systematic reviews along with the protocols of reviews currently in progress. The systematic reviews in the Cochrane database include interventions (therapy). These are very comprehensive reviews and can

be found via various search engines such as Ovid, PubMed, TRIP Database, SumSearch, and the Cochrane site. The Cochrane Database also includes the Cochrane Anesthesia Group (http://www.carg.cochrane.org/en/index.html), which produces reviews in the following 8 areas of anesthesia: (1) ambulatory anesthesia and anesthesia outside the operating room, (2) anesthesia and medical disease, (3) drugs in anesthesia and intensive care medicine, (4) perianesthetic and perioperative care medicine, (5) postanesthetic unit and intensive care unit, (6) prehospital medicine, resuscitation, and emergency medicine, (7) regional anesthesia, (8) technology in anesthesia and intensive care medicine. This is a great resource when faced with a common clinical question that has to be answered in a limited time.[13] The reviews are periodically updated; however. it is good practice to look at the date of last update and deduce if the conclusions are still relevant at the time they are needed.

2. DARE (Database of Reviews of Effects): This is a free database consisting of critically appraised summaries of non-Cochrane systematic reviews. It contains more than 6,000 quality-assessed reviews. DARE is produced by the reviewers and information staff of the National Health Services' Centre for Reviews and Dissemination at the University of York, England, and consists of structured abstracts of systematic reviews

Table 2. Systematic Reviews, CATs, and Guidelines*

Resource	Vendor/Supplier	Availability	Cost	URL
Cochrane Database of Systematic Reviews	Cochrane Collaboration	Can be searched using: *Wiley InterScience Cochrane site *PubMed *Ovid MEDLINE *Scopus *TRIP (Turning Research into Practice) *SumSearch	Abstracts are free, but not full records. Provides institutional licenses or user can access individual reviews on a pay-per-view basis. Access is for 24 hours.	http://www.cochrane.org/reviews
DARE (Database of Reviews of Effects)	A stand-alone resource included in the Cochrane Library	Can find Reviews using: *SumSearch *TRIP *Ovid MEDLINE *PubMed	Free	http://www.cochrane.org/docs/CLdbaseinfo.htm
PIER (Physician Information Education Resource)	American College of Physicians (ACP)	ACP Web site if an ACP member. Otherwise, the STAT!Ref search Database from Teton Data Systems can be used.	Free to ACP members. Otherwise, must use through an institutional subscription.	http://acponline.org
Clinical evidence	British Medical Journal (BMJ) Publishing Group	BMJ-provided Web site	Pay-per-view, one year personal subscription, or institutional subscription.	http://clinicalevidence.bmj.com
US National Guideline Clearinghouse (NGC)	Agency for Healthcare Research and Quality (AHRQ), U.S. Department of Health and Human Services	*AHRQ supported Web site *PubMed *Ovid MEDLINE *SumSearch, *TRIP	Free	http://www.guideline.gov/

*It is important to check with the medical library with which the clinician is affiliated with to find out if fee-based resources can be accessed through the library's institutional subscription or license to the above resources.

from all over the world. DARE records cover topics such as diagnosis, prevention, rehabilitation, screening, and treatment. The abstracts are accompanied by a commentary indicating the strengths and weaknesses of the process used for the review. The database contains more than 500 abstracts related to the practice of anesthesia.

3. PIER (Physician Information Education Resource): Provided by the American College of Physicians (ACP), this resource offers compendia of evidence on the effects of common clinical interventions, providing explicit recommendations. PIER has a number of synopses related to cardiac anesthesia such as perioperative management of congestive cardiac failure (Fig 1), rhythm and conduction abnormalities, and perioperative management of diabetes mellitus.

4. Clinical Evidence: Clinical Evidence, from the *British Medical Journal*, provides information on therapies for numerous conditions; however, this resource focuses on summarizing the strength of the evidence available for benefits and harms of specific treatments. Clinical Evidence uses systematic reviews, RCTs, and observational studies to find the best evidence available regarding therapies. If no good or conclusive evidence exists for a treatment, it will indicate this as well. Rather than suggest or promote specific interventions, physicians are encouraged to examine the evidence for each therapy to decide what action to take. Information on new evidence for each condition is updated every 6 months.

5. US National Guidelines Clearinghouse (NGC): This resource contains both US and international evidence-based clinical practice guidelines. The NGC also groups guidelines that cover similar topics and offers synthesis of

these. In addition, clinicians can find expert commentary of important issues related to the development, use, and attributes of clinical guidelines in general.

The following list RCTs, cohort studies, case-control studies, and case series/reports (Table 3):

1. Medline: This is a comprehensive and extensive database of biomedical literature that is updated daily. Currently, it contains more than 16 million references to journal articles, including citations from approximately 5,200 worldwide journals in 37 languages, focused on biomedicine. Created and compiled by the United States National Library of Medicine and the National Institutes of Health, Medline is intricately linked to PubMed, a free interface for searching Medline material. PubMed has more than 19 million citations and links from article references to articles about the same or similar topics, articles that cite the specific reference, and the publishers' versions of electronic full-text copies of articles. Most of these full-text versions are not provided for free by the publishers, however, and clinicians may need to pay for each article. Medline can also be searched using Ovid or Scopus interfaces.

2. PubMed Clinical Queries: This feature in PubMed allows physicians to search Medline by restricting the search to the type of question the physicians are trying to answer (which they label etiology, diagnosis, therapy, prognosis, and clinical prediction guides). It brings back results that are likely to have direct clinical application based on the type of question identified.

3. EMBASE: This database contains more than 19 million indexed records from more than 7,000 peer-reviewed journals across all disciplines and areas of

Fig 1. The ACP-PIER synopsis on perioperative management of congestive heart failure. (Color version of figure is available online.)

Table 3. RCTs, Cohort Studies, Case-Control Studies, and Case Series/Reports*

Resource	Vendor/Supplier	Availability	Cost	URL
MEDLINE	U.S. National Library of Medicine and National Institutes of Health	*PubMed interface to the MEDLINE® database, *Ovid MEDLINE by WoltersKluwer *Scopus, an Elsevier product	PubMed Gateway is free to use. Individual subscription available for Ovid's interface to Medline	www.ncbi.nlm.nih.gov/pubmed http://www.ovid.com
PubMed Clinical Queries	U.S. National Library of Medicine and National Institutes of Health	*PubMed *SumSearch *TRIP	Free	www.ncbi.nlm.nih.gov/entrez/ query/static/clinical.html
EMBASE	Elsevier	*Elsevier's EMBASE site *Scopus	Need to use institution subscription	http://embase.com/
Scopus	Elsevier	Elsevier's Scopus site	Only provides institutional licenses	http://scopus.com

*It is important to check with the medical library with which the clinician is affiliated with to find out if fee-based resources can be accessed through the library's institutional subscription or license to the above resources.

health sciences research. However, EMBASE searches across journals and resources that have a focus on drugs and allied health disciplines.

4. Scopus: This is a large abstract and citation database covering literature in the fields of physical, life, medical, and social sciences from more than 18,000 peer-reviewed journals. More than half of Scopus' content originates internationally, and references go back to 1996. Scopus also searches Web sites, patents, trade publications, and conference papers.

The following resources list expert opinion (Table 4):

1. UpToDate: Many physicians get the information they need by asking colleagues who are considered "experts" in the field, or people with clinical experience in the particular field.[14,15] UpToDate (UpToDate Inc, Waltham, MA) is an online version of collegial information. This resource provides synthesized topic reviews written by clinical experts. Each review provides an overview of the condition or topic and offers explicit recommendations. Currently, it covers more than 7,700 topics in 14 different medical specialties including cardiology although not specifically anesthesiology. UpToDate also includes a section on new recommendations and one with information for patients. This type

of resource is comparable to an online text book and is very easy to use.[16]

2. eMedicine: This is a peer-reviewed clinical knowledge base from WebMD (WebMD LLC, Atlanta, GA) containing more than 6,500 clinical review articles in 59 medical specialties written by physician contributors. Whereas WebMD material focuses primarily on providing health and medical information to consumers, eMedicine's audience is health care professionals. The format for eMedicine is similar to that of a textbook, providing a large amount of background information and recommended guidelines. It has a section on perioperative care that includes topics of interest to anesthesiologists.

3. MD Consult: This suite of resources, compiled by Elsevier, includes information from different types of materials. Clinicians can use MD Consult to search more than 50 medical reference books and online journals that often link to full-text versions of articles from Elsevier-published journals. This resource also provides access to most of the Clinics of North America and weekly reviews of new developments from government agencies and medical conferences. In addition, MD Consult contains information on drug resources, clinical images, practice

Table 4. Expert Opinion*

Resource	Vendor/Supplier	Availability	Cost	URL
UpToDate	UpToDate, Inc, a division of WoltersKluwer	UpToDate Web site	An individual subscription of $495 for the first year and $395 to renew. Pricing is cheaper if clinicians immediately subscribe for 2 or more years.	http://www.uptodate.com
eMedicine	WebMD	WebMD's eMedicine site	Free	http://emedicine.medscape.com/
MD Consult	Elsevier	MD consult Web site	Individual subscription of $349/y or $50/ mo. Institutional pricing also available.	http://www.mdconsult.com

*It is important to check with the medical library with which the clinician is affiliated with to find out if fee-based resources can be accessed through the library's institutional subscription or license to the above resources.

Table 5. Databases for Cross-Platform Searching*

Resource	Vendor/Supplier	Availability	Cost	URL
TRIP (Turning Research into Practice)	TRIP Database, Ltd	TRIP Database, Ltd site	Free	www.tripdatabase.com
SumSearch	University of Texas Health Science Center, San Antonio (UTHSCSA)	UTHSCSA's SumSearch site	Free	http://sumsearch.uthscsa.edu/

*It is important to check with the medical library with which the clinician is affiliated with to find out if fee-based resources can be accessed through the library's institutional subscription or license to the above resources.

guidelines, patient education handouts, and online continuing medical education opportunities.

The following index cross-platform searching (Table 5): The interdisciplinary nature of anesthesiology demands that clinicians search multiple journals to get the most relevant literature. When the information needed has to be retrieved from primary sources, systems that search in multiple databases save time and yield relevant results.

1. TRIP: This is a single search system for more than 150 health databases and other evidence-based resources such as systematic reviews and clinical guidelines from various countries. It also has 29 subspecialist subsections, including one for anesthesia which can search across various journals such as *Pain*, *Anesthesiology*, *Anaesthesia*, *Anesthesia and Analgesia*, *British Journal of Anaesthesia*, *Clinical Journal of Pain*, *Acta Anaesthesiologica Scandinavica*, *European Journal of Pain*, *European Journal of Anaesthesiology*, and *Regional Anesthesia and Pain Medicine*. TRIP is a free resource, but the citations it brings up are often not available free of charge.

2. SumSearch: This resource, created by the University of Texas, allows clinicians to search multiple medical databases at the same time. SUMSearch searches such resources as the National Library of Medicine, DARE, and the NGC. In addition, anesthesiologists can limit or filter their search results by question type (which they define as intervention, diagnosis, prognosis, or etiology/causation, in addition to others such as "adverse treatment effects").

There are some terms that are commonly used when describing search strategies. It is important to understand what they mean and when they can be helpful.

- MeSH (Medical Subject Headings) Database: It refers to the US National Library of Medicine's controlled vocabulary used for indexing articles for MEDLINE/PubMed. MeSH terminology provides a consistent way to retrieve information that may use different terminology for the same concepts. MeSH terms are arranged in a hierarchical fashion with more general terms leading to more focused terms.[17] For example, a clinician looking for literature on Aprotinin could look up Aprotinin in the search box of the MeSH database. The MeSH database will retrieve results with Links to all articles referring to Aprotinin or the ones where Aprotinin is the major topic (Fig 2). Using the MeSH database helps clinicians find the articles they might otherwise have missed by simply searching various key words that authors may or may not have used.
- Boolean operators: Boolean logic operators help define relationships among search terms. The 3 boolean operators are "AND," "OR," and "NOT." Searchers use "AND" to expand a search to retrieve only citations that include all of the search terms (either in a key word search or a search using MeSH headings).[18] The operator "OR" opens the search up to include citations that contain any one of the researcher's search terms. Finally, "NOT" restricts the search so that citations with a specific term in either their indexed vocabulary or within the abstract and text are not retrieved by the search. Clinicians can use boolean operators in their search string to help refine their search strategy. For instance, searching "Amicar AND Aprotinin" will retrieve articles that discuss both drugs. However, the search "amicar OR aprotinin" will bring back a set of articles that are about one of either search term; a much larger set of citations than the search using "AND." Typically, when searching most databases, the boolean operators should be typed in as all capital letters to identify their use as boolean terms and not terms associated with the search strategy.

Scenarios

Specific scenarios will help illustrate when and how an anesthesiologist might use many of the resources described previously.

Scenario 1: It is 3 AM and the patient being wheeled down for emergent coronary artery bypass graft surgery has a history of heparin-induced thrombocytopenia. The anesthesiologist decides to use a heparin alternative for anticoagulation. How does he/she decide which drug to use?

Using Google (as some physicians do) with the search terms "heparin-induced thrombocytopenia and cardiac surgery" will result in 29,000 hits. Just searching HIT on PubMed will retrieve 9,703 results with the first article retrieved being one on a DNA damage model. This is an unwieldy number of results to read through, and the authority behind many of these sites may be uncertain or unreliable. However, using a structured process can yield relevant, focused literature in less time. Applying the steps discussed earlier can save time in getting the information needed:

1. Step 1: Formulate the question. Using the PICO method (see earlier), the question would read as follows: In patients with heparin-induced thrombocytopenia (population), does the use of direct thrombin inhibitors (intervention) rather than heparin (comparison) result in decreased morbidity (outcome)?
2. Step 2: This is a therapy question.
3. Step 3: This question is best answered with an RCT or systematic review.
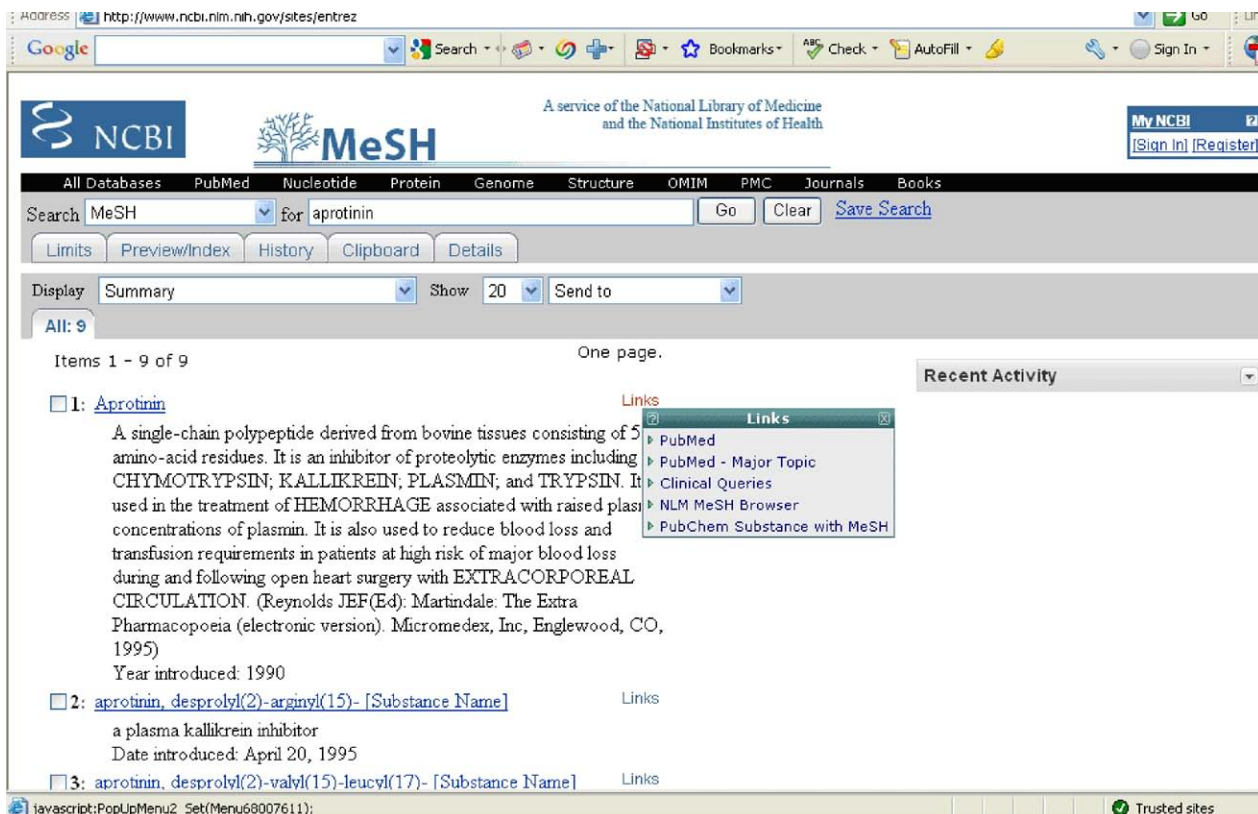
Fig 2. The Medical Subject Heading utility of PubMed. Notice the links feature, which retrieves articles in PubMed in which aprotinin is the main topic. (Color version of figure is available online.)

4. Step 4: Using the clinical queries utility of PubMed (Fig 3), inserting the search phrase "heparin induced thrombocytopenia" and "cardiac surgery" and checking the "therapy" box with narrow search criteria bring the number of retrieved articles to just 12 (Fig 4). The third article in this list focuses on the EVOLUTION trial comparing patients who received bivalirudin for on-pump cardiac surgery with those receiving heparin and protamine and found that mortality, 24-hour blood loss, overall incidence of transfusions, and duration of surgery were similar between the 2 groups. The "related articles" link leads searchers to other relevant papers addressing this topic. Because the most relevant articles favor the use of bivalirudin as a safe alternative, the anesthesiologist opts to use bivalirudin for anticoagulation in this patient.

In this scenario, it also is useful to check to see if there are available guidelines on patients with heparin-induced thrombocytopenia. A search in the National Guidelines Clearinghouse (Fig 5) will retrieve 9 guidelines when searching by condition; in this case, it was "thrombocytopenia." The first one is specific to heparin-induced thrombocytopenia and was created by the College of Chest Physicians.
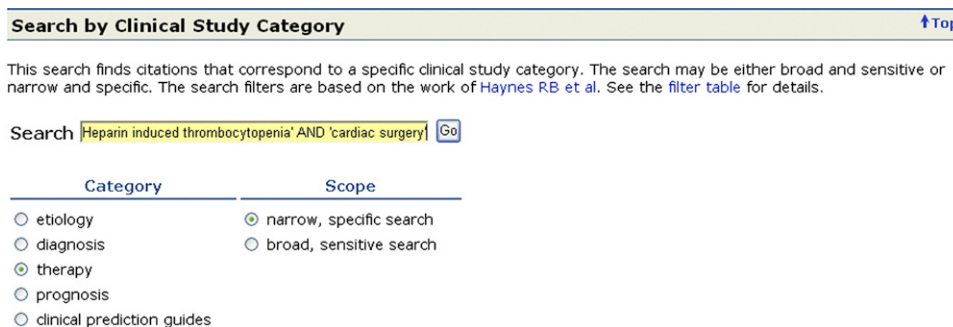

Fig 3. The PubMed Clinical Queries page. The search is narrowed down by the type of question; in this case, therapy as well as the scope. (Color version of figure is available online.)
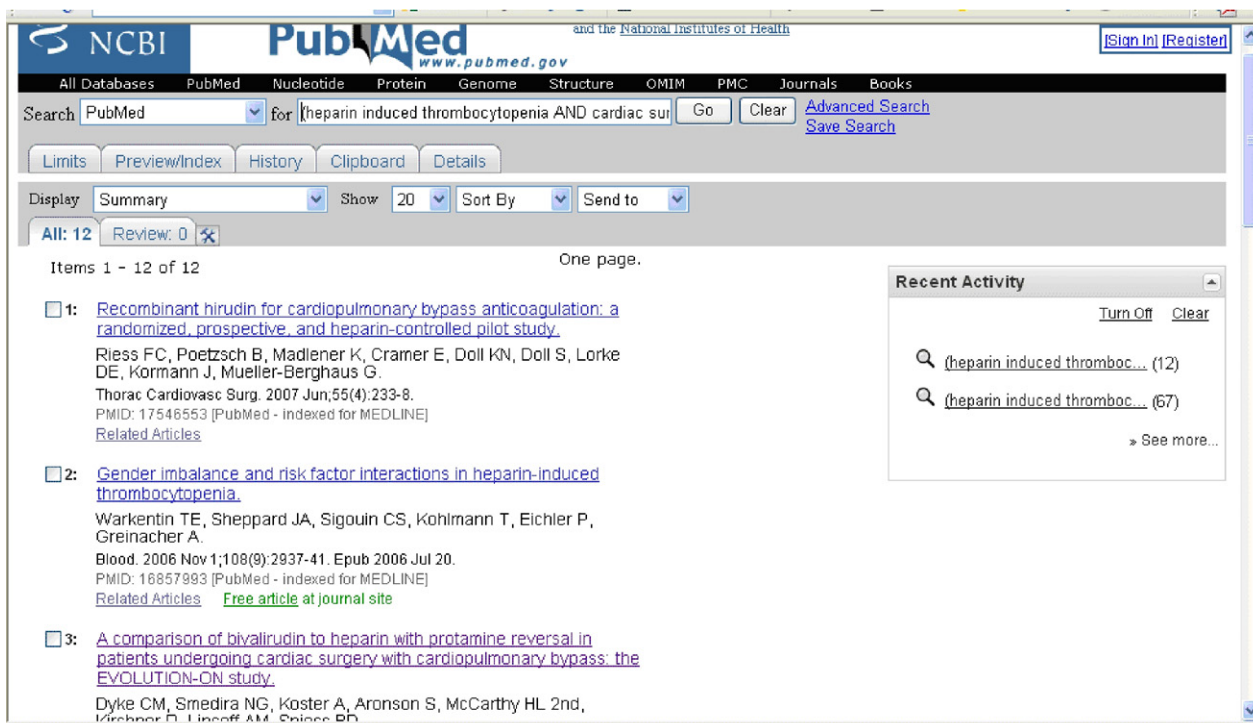
Fig 4. The Clinical Queries utility of PubMed with the search phrase "heparin induced thrombocytopenia" AND "cardiac surgery" and checking the "therapy" box with "narrow" search criteria yields 12 articles. (Color version of figure is available online.)

Scenario 2: An anesthesiologist is seeing a patient in the preoperative area who is very apprehensive regarding anesthesia. The patient presents the anesthesiologist with printouts from a web site regarding awareness under anesthesia. How should the clinician guide the patient?

Any patient approaching his/her first surgical experience is likely to be anxious about undergoing anesthesia. Many patients try to get more information to alleviate their concerns. The Internet is a very popular resource for patients seeking information on medical conditions, medications, procedures, and information regarding their physicians and health care facilities.

The Pew Internet and American Life Project found that 80% of adult Internet users, or almost half of all Americans over the age of 18 (about 93 million), say they have researched at least one specific health topic at some point.[19] Although many of the users consider themselves "tech savvy," not many of them are able to evaluate the reliability and credibility of the information they get from the Internet. Increasingly, physicians find themselves in the role of patient guide, directing them to the many
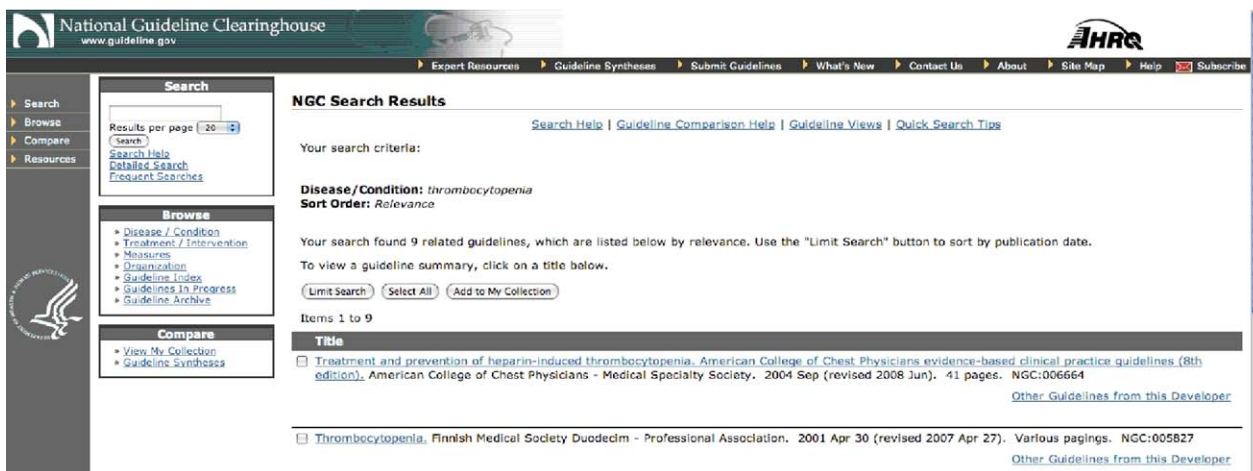

Fig 5. The NGC page showing results for thrombocytopenia with 9 related guidelines. (Color version of figure is available online.)

authoritative sites on the Web. Directing and helping patients understand relevant information also relieves anxiety. Anesthesiologists have access to a number of excellent and free patient education resources.

The American Society of Anesthesiologists (ASA) has very useful information for patients on their site (www.lifelinetomodernmedicine.com) (Fig 6) including awareness under anesthesia, how anesthesiologists manage acute, chronic and cancer pain, and how to prepare children for anesthesia.

MedlinePlus was created by The U.S. National Library of Medicine along with the National Institutes of Health (www.Medlineplus.gov). It is a health information database covering more than 800 conditions written specifically for consumers. The MedlinePlus search engine brings together information on diseases and procedures from numerous reliable sources.[20] For instance, if the physician types in "anesthesia," MedlinePlus immediately presents links to sites created by the American Society of Anesthesiologists, the National Library of Medicine, the Patient Education Institute, and other society sites (Fig 7). Most institutions and anesthesia groups now have their own Web sites that have information for patients including contact information for additional questions. These sites also include specific information for patients regarding parking, hospital stay, and so on.

The anesthesiologist in this scenario discusses issues surrounding awareness under anesthesia with the patient and guides him to the ASA Web site and patient education resources listed there (http://www.asahq.org/patientEducation).

Scenario 3: A physician wants to keep current with the literature in his specialty but feels that he has inadequate time to find articles relevant to his interest in the various journals published. What options does he have to stay current without putting a huge demand on his time?

There are a number of tools now available to busy physicians to keep abreast of the advances in their field of interest. One solution is to subscribe to an alert service that scans specified journals and sends subscribers the table of contents. Physicians can subscribe to the table of contents from each journal Web site or use alert services that scan multiple journals. An example of an alert service that provides an online table of contents from multiple journals is AMEDEO (http://amedeo.com). AMEDEO arranges journals based on 25 medical topics with various subtopics. For instance, the subtopics of "Anesthesia" and "Pain Management" are listed under the category "Critical Care." The subtopic of "Anesthesia" contains a list of 31 journals important to the field of anesthesiology. Physicians can either click on a listed journal and get its table of contents for the previous 12 to 24 months, or they can sign up for AMEDEO's free e-mail service. By selecting the clinician's favorite journals in any category, the clinician will receive weekly emails with a list of articles published in the journal subset. E-mails typically contain bibliographic information for each reference (authors, title, journal, year of publication, and volume, pages) including a link to the article's abstract on PubMed.[21] Individuals can also subscribe to podcasts of summaries of journal articles (eg, *New England Journal of Medi-*
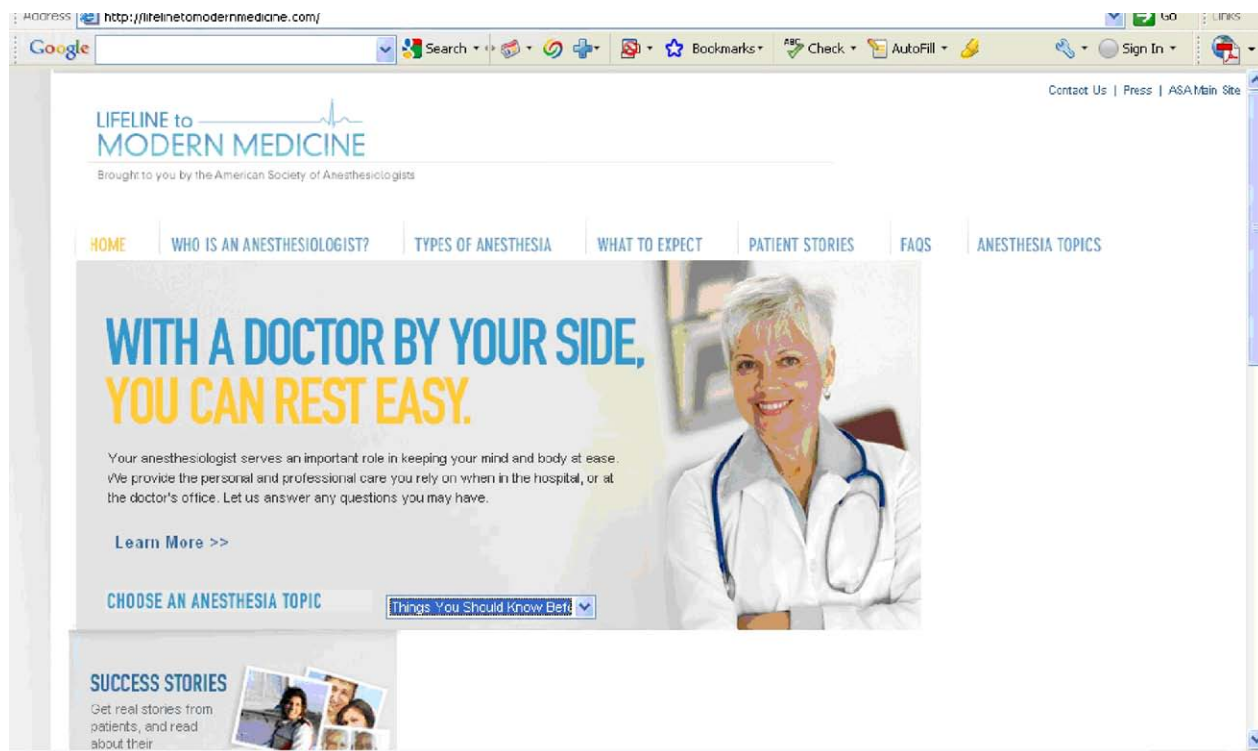

Fig 6. The ASA patient-information site. (Color version of figure is available online.)
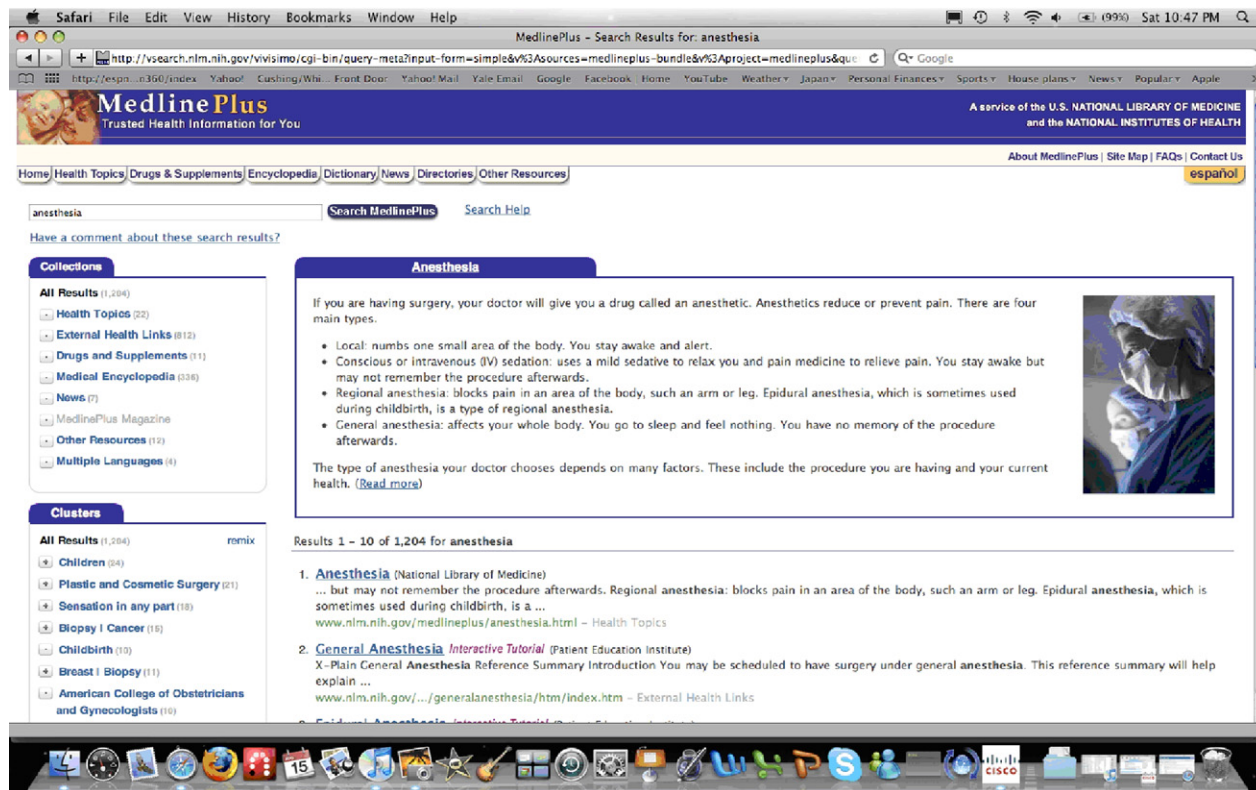
Fig 7. The MedlinePlus Anesthesia information page. (Color version of figure is available online.)

cine) or summaries of systematic reviews from The Cochrane Library and listen to them at leisure.

"Google Alerts" allows researchers to go beyond the published literature to keep abreast of advances in specific subjects. Clinicians can choose specific search terms to create a Google Alert, and e-mails will be automatically sent when there are new Google results for the search terms in different media like News, Web, Blogs, Video, and so on. Clinicians can create as many alerts as they wish, limited only by the time they would have to actually read all of them.

A number of journal Web sites, such as "Evidence Based Medicine" created by BMJ (http://ebm.bmj.com/), now offer the option of tracking topics, authors, or articles of interest by e-mail alerts or getting the new issue tables of content, publication ahead of print articles, and journal announcements directly to your inbox. Many of the services like AMEDEO are free with registration required for e-mail correspondence. Weekly information updates are compiled by specialists dedicated to the rapid distribution of medical knowledge.

Another useful tool is to save the search strategy of interest in PubMed and to schedule the database to automatically run the search topics in which the clinician is interested. Searchers can save any search strategy they create on PubMed using the "MyNCBI" feature, decide how often PubMed should rerun the search strategy (daily, monthly, or yearly) to find any new citations published, and have the results sent to the searcher via e-mail or through a Really Simple Syndication reader. Many other databases allow searches to be saved in a similar

manner, and they can be repeated when needed to find the latest publications on a subject. Ovid's interface to the Medline database and Scopus are equipped with this feature.

Scenario 4: A patient in the preoperative clinic before femoral-popliteal bypass surgery complains of intermittent mild chest pain. The medical student asks whether the patient needs more cardiac testing before surgery. The anesthesiologist wants to retrieve the latest American College of Cardiology–American Heart Association guidelines that she recalls were published in the journal Circulation in 2007. How does she quickly find the article?

To find a specific publication, PubMed's "Single Citation Matcher" is an excellent tool (Fig 8). Single Citation Matcher is located under the category "PubMed Tools" in the center of the search page. The searcher fills out a form with as much information about the publication as they have. For instance, if the searcher only knows the author and year of the publication, they can type these into those two specific fields. PubMed will search for all citations indexed in the database that match those criteria. Obviously, the more information the searcher has about an article (journal title, volume, page number, and so on), the more likely that PubMed will find the single, specific citation in which the searcher is interested.[22]

In addition to "Single Citation Matcher," PubMed has recently updated their "Advanced Search Feature," which allows searchers to type in key words and apply them to specific fields of a citation such as the author's name, title of the article, and date.

Fig 8. PubMed's Single Citation Matcher page. Filling in as much information as possible ensures the retrieval of intended citation. (Color version of figure is available online.)

Even a generic search for "ACC-AHA" guidelines will return relatively few results (in this case 6); the 4th article retrieved is the article of interest. This is also a useful application to retrieve a number of citations that meet the specific criteria that the searcher has in mind. Because the article refers to guidelines, the anesthesiologist can also get the citation from the National Guidelines Clearinghouse site.

In this case, the anesthesiologist uses the "Single Citation Matcher" feature of PubMed and puts in the known information, namely the name of the journal, year, and the title words "ACC-AHA". She retrieves 8 results of which the 4th is the article of interest for the medical student.

Scenario 5: An anesthesiologist is scheduled to take care of a 44-year-old gentleman who is coming for coronary artery bypass grafting. The patient is very apprehensive about waking up in the intensive care unit with a breathing tube and wants to know if he can be extubated in the operating room if the procedure is uncomplicated. The anesthesiologist would like to offer this option but wants to see if there is literature to support the decision. Which resources should he use?

A systematic review would contain the most comprehensive information on whether this procedure is a safe option for the patient. The authors of a systematic review will have reviewed all of the primary studies on this topic, appraised them, and summarized the studies so other clinicians can review the current evidence on the efficacy of this procedure. Systematic reviews are excellent sources of information for questions on intervention or therapy.[23] A good resource for finding well-constructed systematic reviews is the Cochrane Database of Systematic Reviews. The Cochrane reviews are in-depth reviews, which makes them very comprehensive but also very dense so they can be difficult to peruse quickly.

The abstracts from the DARE database offer a short synopsis of the systematic review and are easy to peruse. Another option is to search TRIP for systematic reviews, guidelines, and other international evidence-based resources. Because TRIP searches across existing databases, a search on "extubation AND cardiac" retrieves links to not only a relevant Cochrane review but also to other sources of information from evidence-based journal clubs, national guidelines, and other reviews including those from DARE.

In the scenario, by searching "extubation" and "cardiac" in the query box, the anesthesiologist immediately found the review for "early extubation for adult cardiac surgical patients" (Fig 9). The summary states that results from 6 controlled trials showed that early extubation after cardiac surgery was safe and could possibly have beneficial effects on hospital length of stay. This allowed the anesthesiologist immediate ability to validate his decision to offer early extubation to the patient.

Barriers to Information Access

The following are some issues that prevent the busy practitioner from accessing literature relevant to a clinical question.

1. The indexing of journal articles is done using MeSH terms, which are semantically limited and do not always express the meaning of the text.[2] Although MeSH terms help focus search, they are not intuitive to use. In addition, the method to finding the most appropriate MeSH terms to use in a search differs among data-
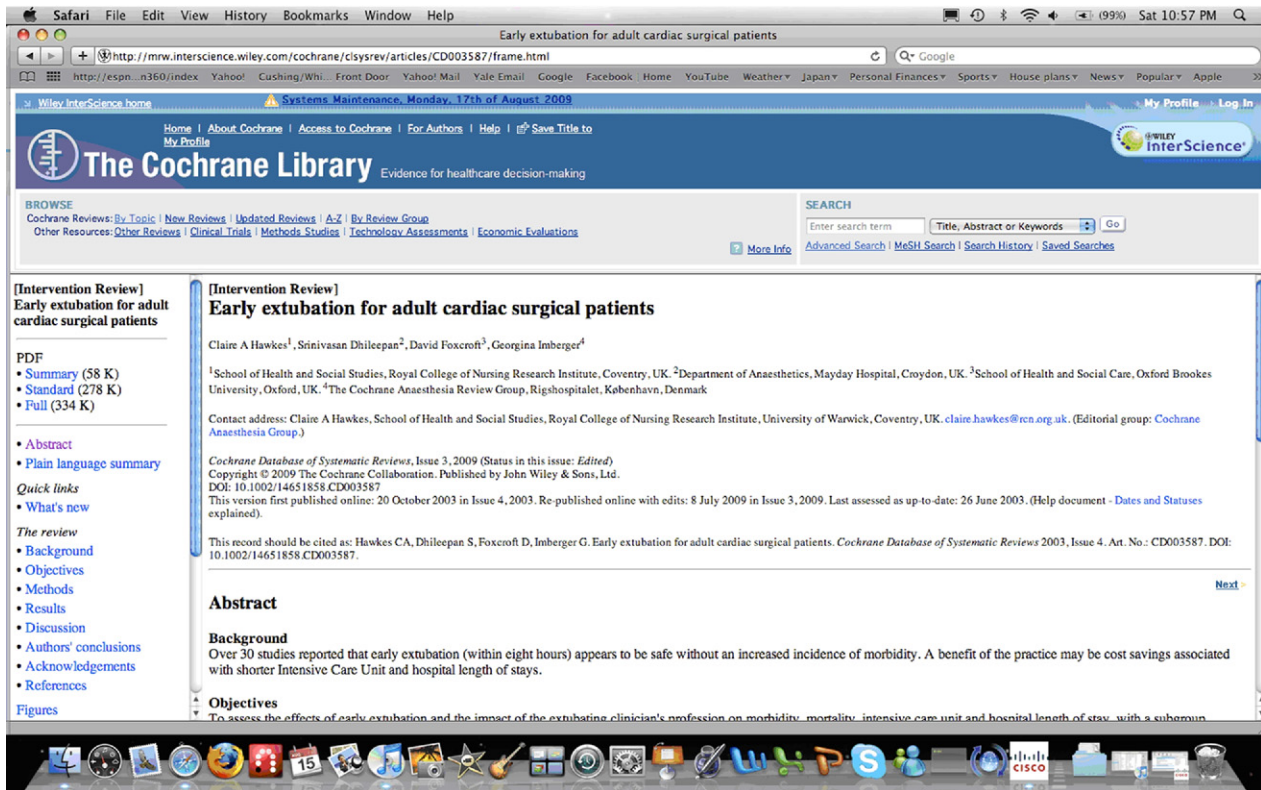
Fig 9. The Cochrane Library Web page showing the review article. It includes a plain language summary at the end. (Color version of figure is available online.)

bases. For instance, finding MeSH terms in PubMed is different from finding them in Ovid's Medline interface. Medical librarians can assist anesthesiologists in understanding and using the correct MeSH terms to bring back the most pertinent references when searching.

2. There is an inherent delay in receipt and indexing of journals, which can vary depending on the organization indexing them. Most publishers submit their references to PubMed before or at the time of publication, so the lag time is not great for references appearing in that database. There are, however, inconsistencies in how search engines post unindexed articles. For instance, PubMed will include article abstracts that do not yet have MeSH terms assigned, but Ovid Medline will not. However, until articles are indexed in PubMed, they cannot be found using a MeSH search strategy but rather only through key word searching. This may mean that a clinician will need to conduct more than 1 search to find all articles on a topic.

3. Finding free citations to articles and publications does not automatically lead searchers to free full-text versions of those articles. Most publishers will require a fee for researchers to access an article often known as "pay-per-view." This does not allow the searcher to copy the article or forward it for distribution to others. If the clinician is affiliated with a facility or institution that has a medical library, he may be able to access an

article through the library's subscriptions to the full text of many journals. However, it is worth remembering that with publishers' costs rising for institutional licenses, many libraries have been forced to cut subscriptions. Almost all libraries will offer free interlibrary loan services, although there may be a wait of a number of days before they can get the article(s) to you. Most databases, such as UpToDate and The Cochrane Library, will allow individuals to pay for access not only to the database but often to a particular group of full text journals as well. Fees for access vary depending on the database and the number of full text journals to which they provide access.

Clinicians in many developing countries can gain access to thousands of full-text journals through the World Health Organization's Health Information Access to Research Initiative (HINARI) project. HINARI provides free or very low-cost online access to the major journals in biomedical and social sciences to local, not-for-profit institutions in developing countries (http://www.who.int/hinari). Currently, more than 150 publishers provide access to more than 6,200 journals through HINARI.

Medical Librarians and Information Specialists are available to assist anesthesiologists in finding the literature they need quickly and efficiently. Anesthesiologists affiliated with hospital or academic libraries are likely to find that they have access to many of the databases and resources described in this article.

In most academic institutions, librarians will work to negotiate institutional licenses that allow clinicians and hospital staff to access databases that index biomedical literature and provide full-text electronic access for many health sciences journals at no cost to the individuals affiliated with their library's institution. Anesthesiologists should feel confident to contact their medical librarians and take advantage of the resources they have to offer.[24]

Sample Medical School Curriculum for Information Management

Most medical schools have begun incorporating information-management skills into the curriculum of their medical students. The Yale University School of Medicine is fairly unique in that its students are required to write an MD thesis. The thesis must espouse a specific hypothesis supported by data, some of which are often found in the medical literature. Because research toward the thesis is such an important aspect of medical students' experience at Yale, the medical school's library has incorporated literature-searching and informatics workshops into the medical school curriculum throughout students' 4 years.

In year 1, librarians offer an orientation to the library and an hour-long session "Find it: Searching Major Databases," which is integrated into the Thesis Research Course. This session is followed by scheduled "drop-in" search clinics. The culmination of this course is the thesis proposal. Supplementing this is a session called "Getting Started With OVID SP: Formulating Your Questions Using PICO, Medical Subject Headings, and Combining and Limiting Searches."

In year 2, the library participates in the Epidemiology and Public Health Course with an integrated session called "Find it: Advanced Searching Strategies." This continues building on skills developed in the first year and is a hands-on small-group session. Supplementing this year is a series of video tutorials on the various evidence-based practice information resources such as The Cochrane Database of Systematic Reviews, ACP's PIER, Clinical Evidence, Clinical Queries in MEDLINE, and TRIP.

Third-year students attend 2 integrated hands-on small-group library sessions as part of their introduction to the clerkship years. The first session is "Find it Fast! Searching Clinical Resources," and the second is "Using Mobile Devices on the Wards."

Finally, in year 4, the library sessions are included in the post–medical school preparation course. A series of "out-the-door" sessions are offered that are designed to update skills and to highlight new tools and resources as well as focus on emerging trends.

Enveloping these course-integrated and special sessions is a well-established "Personal Librarian" program, which matches matriculating students to a professional librarian, a relationship that lasts until after graduation. Personal librarians offer individualized assistance for almost anything, from library policies/procedures and copyright questions to thesis research.[25] There is also self-paced learning material that is always available to students and faculty who are eager to keep current with ways to search the medical literature and evidence-based resources.

CONCLUSION

Anesthesiologists exhibit strong biases in the way medicine is practiced, influenced by knowledge and experience. However, clinical decision-making should incorporate the results of formal research. Established guidelines and traditional practice are constantly challenged for cost-effectiveness and safety profiles. Physicians strive to assimilate the best evidence into daily practice. The skills necessary to practice evidence-based medicine as well as to manage information overload are not adequately addressed in residencies and fellowship programs worldwide, although medical schools are beginning to incorporate information seeking skills into their curriculum.[26] The need for a dialog regarding the form and content of information management strategies is apparent. Working in an interdisciplinary environment, anesthesiologists are uniquely positioned to disseminate new knowledge and provide leadership in developing perioperative practice guidelines using current information to improve patient outcomes. By following simple steps, anesthesiologists and other clinicians can more quickly and efficiently find relevant and reliable information to help them make the best decisions for their patients.

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