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SEMINAR ON COMPUTER APPLICATIONS FOR THE CARDIOLOGIST—II

Edward A. Geiser, MD, FACC, David J. Skorton, MD, FACC, *Guest Editors*

Application of the Office or Home Computer to Searching the Medical Literature

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Search of the medical literature has, until recently, most often been conducted by medical librarians. The recent development of "user friendly" systems and competition among an increasing number of commerical and noncommercial vendors now provide the opportunity to personally conduct literature searches using a home or office computer without enormous investment in time, training or equipment.

Hardware requirements and general principles of computerized literature searching are described, and the various services available for individual subscription are summarized, including National Library of Medicine (NLM) MEDLINE; Bibliographic Retrieval Services (BRS) and BRS/Saunders Colleague; PaperChase; Dialog/Knowledge Index; American Medical Association (AMA) Minet; and MEDIS.

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The Problem

A fixture of nearly every cardiologist's office is the more or less unruly pile of journals awaiting perusal. Reducing, if not eliminating, the backlog of unread journals is a task rivaling that of Sisyphus; objective evidence of the magnitude of the problem was recently provided by an actual count of 17,407 pages of text in a single year (1983) in the four major cardiology journals published in the United States (*Circulation, Journal of the American College of Cardiology, American Journal of Cardiology, American Heart Journal*) and the three major English language cardiology journals published in other countries (*British Heart Journal, European Heart Journal, International Journal of Cardiology*) (1).

Increasing in proportion to the amount of new literature, of course, is the problem of assimilating, recalling, filing or retrieving a desired article. There are many viable systems for literature retrieval that do not utilize computers, including a personal filing system arranged by major topics. This time-tested option has the advantages of personalization, usually very rapid and convenient access and, perhaps most important, availability of the full text of articles if these are saved. On the other hand, in addition to the time and space required to keep such a file up to date, personal journals must be ripped (alternatively, photocopies can be made or reprints can be written for, but this is cumbersome and uncertain; simpler, although expensive, is to receive *two* copies of each issue of major journals, ripping and filing one copy by topic, and binding or arranging the other chronologically by volume). Among many other nonautomated options for literature retrieval are the use of annual review volumes (2) or topic-oriented bibliographic lists compiled by experts and periodically published in various journals (3–5), crossreferencing from review articles or books or using abstract sections provided by various journals.

For the physician interested in automatic, periodic and very rapid updating, *Current Contents* (Institute for Scientific Information, Philadelphia) may be perused weekly. Other updating services include *E-Journal Cardiology* (available in print or on-line, US Telecom/Information Companies of America, Philadelphia); *Ascatopics* (citations with document delivery, Institute for Scientific Information, Philadelphia); and Monthly Literature Service (MLS), a subscription service available from the library of the American

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College of Cardiology which provides monthly references, many with abstracts, in any of 21 subject areas of cardiovascular disease (angina, arrhythmias, catheterization, congestive heart failure, coronary artery disease, coronary artery spasm, echocardiography, and so on up to rehabilitation, valvular heart disease and, new for 1986, computers in cardiovascular disease).

In any medical library, *Index Medicus* can be searched by hand. The sheer bulk of this index (14 volumes for 1985 alone!), the need to know the precise year of a particular article to avoid searching through many yearly volumes and the vast unwanted bulk of articles in other fields of medicine and in many languages make manual use of *Index Medicus* a task only for those strong of heart and sinew.

The world's medical literature in the form of *Index Medicus* has been computerized for some years by the National Library of Medicine (NLM) as the MEDLINE data base. This collection of bibliographic citations from more than 3,000 biomedical journals dating back to 1966 can be searched with small home or office computers.

Most physicians have used the MEDLINE data base for bibliographic searches done by medical librarians; at the Cornell Medical Library more than 2,400 such searches are requested yearly and performed by library personnel. The charge for such a search at Cornell is $15, approximately the average cost to the library of the search. Several pharmaceutical companies have made automated bibliographic retrieval services available to physicians, so that even those cardiologists without easy access to a medical library can usually obtain this service, sometimes with a portable interactive terminal brought by the pharmaceutical company representative to the physician's office.

In the past, literature searches were done by experienced librarians using the original and seminal system, National Library of Medicine (NLM) MEDLINE. Unlike today's "user friendly" systems, MEDLINE has occasionally been characterized as "user hostile" (!), although those experienced with the system become accustomed to its quirks and find it to be eminently cost effective even in comparison with its many newer and more glamorous competitors. In response to the difficulties of using NLM, and because NLM was for many years limited to institutions, several commercial vendors leased access to MEDLINE, developed interactive software to ease searching and offered access to individuals. Healthy competition has developed among several vendors, with the result that new and attractive features are constantly being added, often for little or no more than the price of the original bibliographic reference service. However, the heart of almost all available commercial services is literature citation searching using MEDLINE. Modern commercial vendors add full texts of certain journals and books; other medical information, particularly relating to drugs; electronic bulletin boards; financial statistics, current events, and dozens or sometimes hundreds of nonmedical data bases; as well as a bewildering and ever increasing number of features to gain a competitive edge.

What is important though, is the fact that it is now possible for any cardiologist with access to a home or office computer to have simple, rapid and inexpensive access to the medical literature with minimal training. This article will summarize available systems and give a brief subjective judgment of advantages and disadvantages of each.

General Requirements

Access to search systems is by terminal or personal computer through a modem and a telecommunications network. A terminal is used alone; a software package like SMARTCOM is needed to allow a personal computer to communicate with the data base. Telecommunications charges, usually local calls to the nearest node of a network, are billed monthly together with computer access time; modems may be either 300 or 1200 baud (30 or 120 characters per second transmission speed, respectively); most services allow use of either speed but have different telephone numbers for access according to transmission rate. A printer is needed if hard copy printouts are desired; most commercial services offer off-line printing for those who either have no printer or do not wish to tie up a printer in producing especially lengthy copy. Document delivery of articles is often available at extra charge.

A password is assigned and required to initiate searching. Billing is usually according to access time used, sometimes to major credit cards, sometimes direct. Hourly rates often vary, with one rate for medical data base access and a similar or higher rate for news, financial services or other information of general interest. There are often one-time registration fees, monthly minimums, discounts for high volume users, varying rates according to time of day, extra charges for extra services and other complexities. Of considerable importance is that many services are not available at all hours of the day. Finally, remember that a telephone is needed, and that line will not be available for other uses for the duration of the search.

General Principles of Computer Literature Searches

A bibliographic data base consists of a set of records containing the following elements: author, title, source (journal), year, institution, subject classifications according to the controlled vocabulary of the *Index Medicus* medical subject headings (MeSH), and sometimes an abstract. Search and retrieval can be done by any one or a combination of these elements, indeed any significant word in the title or abstract can be used as a key word.

Subject heading and key word. Most searches will begin with an author's name, a subject or topic or a key

word. Care must be taken with nuances such as spelling or initials; for example, a MEDLINE search for recent articles written by SCHEIDT S yielded one group of references while another request using SCHEIDT SS gave a different set of citations. Subject headings and key words may be used either as is or as word stems. For example, if "pacing" is the key word, many systems, with the proper command, will also select references containing "pacemaker," "pacemakers," "pacing, artificial," and so on. On the other hand, some systems are excruciatingly specific. NLM/MEDLINE, for example, generally responds only to subject headings that follow the exact format of *Index Medicus*, so that the terms "acute myocardial infarction," "acute infarction," "MI" or "heart attack" will not elicit any useful information—only "myocardial infarction" will get the search going. It is possible to search with related terms as key words rather than subject headings.

Simultaneous searches of multiple combinations. Aside from the ease, speed and completeness of the search, the enormous power of computerized literature searching is due to the ability to search simultaneously for multiple combinations and permutations of elements of the bibliographic citation. For example, a search routine might consist of a command to call up the set of all articles with the subject heading "myocardial infarction," and then another set of all articles with the subject heading "echocardiography" and finally focus in on the few articles common to both sets, that is, classified under both subject headings and thus, one hopes, relevant to the topic "echocardiographic findings in acute myocardial infarction." All systems allow queries for two or more key words in the title only, within the same sentence or paragraph or adjacent to one another. For example, most systems will be able to retrieve articles in which the title or abstract contains the words "smokeless" and "tobacco," and on proper command will supply only articles in which those two words appear next to each other. Searches can also be made for one word *without* the second word (for example, "neoplasm" without "animal" when only human studies are desired). Most systems allow tailoring of the search by language of the article, year of publication or total number of citations desired (usually given chronologically, most recent first). Searches can also be made more specific by specifying review articles only, and by differentiating whether a subject heading is of major or minor importance (relevance) to the article.

"Explode" function: cross-referencing. The inverse problem is to find all possible relevant articles. Either the searcher or the access software must be able not only to search under the subject heading, key word or title immediately available, but also to expand the search to related subject areas. Some systems cross-reference and expand the search to related areas, either by suggesting other subject headings to the searcher or by automatically providing citations from related areas. Many systems offer an "explode" function, whereby a search requested in an area such as "heart valve diseases" can be expanded or "exploded" to encompass all citations filed under aortic valve stenosis, aortic valve insufficiency, mitral valve insufficiency, mitral valve prolapse, mitral valve stenosis, pulmonary valve insufficiency, pulmonary valve stenosis, tricuspid valve insufficiency, tricuspid valve prolapse and tricuspid valve stenosis. Giving one command to "explode" is obviously simpler and faster than typing in multiple subject headings manually, but does create the potential problem of producing large numbers of largely irrelevant or unhelpful citations.

The problem in most searches is too much information, not too little, and the consequent need to focus the inquiry to the most relevant (and in any case a manageable number of) articles. A query on some broad topic such as "myocardial infarction" can easily yield several thousand citations in a single year. Refining and focusing searches takes experience and practice. All the major vendors provide hotlines, usually "800" telephone numbers, for help with problems, and this assistance can often be used even while online during a search.

Individual Bibliographic Search Services (Table 1)

1. NLM MEDLINE. This is the prototype of all other services, originally available only to medical libraries but now offered to individual subscribers. Indeed, The National Library of Medicine (NLM) is now offering training in literature searching to individual health professionals at various regional sites. Relatively complicated to learn, MEDLINE may provide fewer irrelevant articles than some other services, and is quite inexpensive (indeed, it is the cheapest of all available search services when used at night according to a recent survey) (6). Higher per minute rates and also slower response times during the day (10 AM to 5 PM Eastern Standard Time) make for increased expense when used then (but still not high on average). As noted previously, the data base extends back to 1966, but is in seven individual files, each encompassing only a few years. The most recent file contains only 1984 to the present; a separate search must be made for each chronologic file desired (although search strategy can be saved and repeated, of course, so this task is not onerous). There is some delay in indexing the most recently published literature and references more recent than about 2 to 3 months may not yet be included, particularly for less important and foreign journals.

Abstracts are available for about 60% of citations. There are 21 additional medical data bases, including drug information, cancer information, historical and ethical information, and so on. There are no nonmedical data bases.

2. Bibliographic Retrieval Services (BRS) and BRS/Saunders Colleague. BRS is a large data base vendor providing access to various bibliographic data bases, in-

Table 1. Characteristics of Bibliographic Search Systems for Individual Use

System	Data Base	No. of Journals	Ease of Use*	Subscription Fee	Monthly Fee	Hourly Cost†		Peak hours	Times Available	Contact
						Peak	Off Peak			
NLM	MEDLINE	>3,000	Difficult	0	0	$22	$15	10 AM–5 PM	24 hours‡	National Library of Medicine 8600 Rockville Pike Bethesda, MD 20209 301-496-6193
BRS/Saunders Colleague	MEDLINE	>3,000	Easy	$75	$15§	$32	$20	6 AM–6 PM	M to Sat 6 AM to 4 AM Sun 6 AM to 2 PM 7 PM to 4 AM	BRS/Saunders 1200 Route 7 Latham, NY 12110 800-833-4707
Dialog	MEDLINE Excerpta Medica	>3,000 >4,500	Difficult	$50‖	0	$36# $84#	NA	NA	M to Th MID to 10 PM F MID to 10 PM Sat to Sun 8 AM to 8 PM	Dialog Information Services 3460 Hillview Avenue Palo Alto, CA 94304
Knowledge Index	MEDLINE	>3,000	Medium	$35	0	NA	$24		M to Th 6 PM to 5 AM F 6 PM to MID Sat 8 AM to MID Sun 3 PM to 5 AM	800-334-2564
PaperChase	MEDLINE since 1975	>3,000	Easiest	0	0	$23**	$23**	None	24 hours‡	PaperChase Beth Israel Hospital 330 Brookline Avenue Boston, MA 02215 617-735-2253
AMA Minet	EMPIRES (subset of Excerpta Medica)	300	Medium	0–$100††	$20§	$39	$39	None	24 hours	AMA/GTE Telenet 12490 Sunrise Valley Drive Reston, VA 22096 800-368-4215
MEDIS	MEDLINE	>3,000	Easy	$200	$50	$30‡‡	$21	7 AM–7 PM	M to F 24 hours‡ Sat MID to 10 PM Sun 6 AM to MID	Mead Data Central P.O. Box 1830 Dayton, OH 45401 800-227-4908

*As assessed by Haynes (6) and estimated by the authors. †Most systems provide additional discounts for high volume users that may be substantial but that usually require more use (for example, >100 searches/month) than is likely for the average individual user. ‡Most systems providing 24 hour service have a brief period, often 5–15 minutes, of nonavailability for daily maintenance. §Monthly minimum, not an extra charge. ‖Fee for initial instruction booklet. #Plus telecommunications $6–10/month. **Plus $0.10 per citation plus $0.10 for abstract. ††No fee for AMA members, $100 for nonmembers. ‡‡Plus $3 per MEDLINE search. NA = not available.

cluding MEDLINE and Excerpta Medica (since 1980), and has a previews section with citations from more than 160 core journals on-line within 10 days of receipt (including *Circulation, American Journal of Cardiology, American Heart Journal* and *British Heart Journal*). BRS After Dark, restricted to the hours 6 PM to 4 AM Monday through Friday, 6 AM to 4 AM Saturday and 6 AM to 2 PM and 7 PM to 4 AM Sunday, offers MEDLINE and Excerpta Medica but no full text and is cheaper.

An individually oriented medical service, BRS/Saunders Colleague, currently includes the bibliographic data bases on BRS as well as complete texts of about a dozen journals (none of major cardiologic interest), texts of about 25 books (Boucek's *Coronary Artery Disease,* Karliner's *Coronary Care* and Brenner's *Hypertension* are the only cardiologic books listed), almost a dozen manuals and directories (including *Cardiology Clinics*) and several drug information services or handbooks. There is also Physician Data Query (PDQ), information about prognosis and treatment, protocols and directories of care providers pertaining to cancer provided by the National Cancer Institute (NCI). Access to numerous nonmedical data bases in life sciences, business, finance, and so on, are available, usually at a slightly higher hourly rate than for MEDLINE or other medical data bases.

BRS was originally developed for institutions and requires considerable training and experience. For individuals, Colleague provides full text and bibliographic services to medical professionals in more user-friendly and menu-driven format (available 22 hours a day, 6 AM to 4 AM Monday through Saturday, and Sunday 6 AM to 2 PM and 7 PM to 4 AM). Colleague is quite flexible in that it provides much menu help to the inexperienced searcher but also allows use of multiple commands without waiting for intervening machine responses or queries, bypassing explanations, menus or aids that would waste the time of the experienced user.

3. Dialog/Knowledge Index. Dialog is another commercially available service, in operation for over a decade, providing access to an enormous number of data bases, medical and nonmedical. More than 230 data bases cover science, technology, business, social sciences, current affairs, and the like. The medical and bioscience data bases include both MEDLINE and Excerpta Medica, several drug-oriented data bases, Biosis Previews, data base on biological and biomedical research, and several others. Dialog has a $50 initial fee for the Guide to Searching, no monthly or minimum fees and varying hourly charges for different data bases, ranging from $15 to more than $150 an hour for a few highly specialized data bases. MEDLINE costs $36 an hour, and Excerpta Medica $84 an hour, plus telecommunications charges of $6 to $10 an hour.

Knowledge Index is a user-friendly service of Dialog, offering a restricted number of data bases evenings and weekends at lower cost. Personal computer users have access to more than 30 data bases in agriculture, books (*Books in Print*), business, computers, education, engineering, government publications, law, magazines and news (indexing of many popular American magazines and newspapers), mathematics, psychology and references. There are five medical data bases, including MEDLINE, international pharmaceutical abstracts, two full text drug information data bases and Biosis Previews. Knowledge Index is quite easy to learn and use but somewhat imprecise in that it cannot be restricted to human services or English language articles. The service has a modest initial subscription fee and no monthly charge or minimum. Both Dialog and Knowledge Index offer an electronic mail service for messages and announcements.

4. PaperChase. Developed by Beth Israel Hospital in Boston, this system allows access to MEDLINE citations since 1975. It is the easiest system to use, but in some hands requires considerably more search time, produces a lower percentage of directly relevant articles and has the highest overall cost according to one comparative study (6). PaperChase is unique in that natural language words or key words will automatically be cross-referenced to the official *Index Medicus* MeSH subject category vocabulary. This is both its strength (one is less likely to miss relevant citations) and its weakness (more citations are generated, using more computer time and also requiring more user time to screen the output for directly relevant articles). PaperChase also unifies spelling variants, plurals, hyphenated and punctuated words and makes suggestions for search strategy.

PaperChase is available 24 hours a day, with no initial subscription cost and no difference in cost for day or night use. It is worth considering for the low volume user because there are no monthly minimum charges.

5. American Medical Association Medical Information Network (AMA Minet). The EMPIRES data base, a part of the AMA/GTE Telenet network, is the one medical citation retrieval service that does not use MEDLINE, but only the indexing service of Excerpta Medica. This service indexes only about 300 clinical journals (including *Circulation, Journal of the American College of Cardiology, American Heart Journal, British Heart Journal* and most journals of interest to cardiologists). One important advantage is that full text abstracts are available in every case; a potential disadvantage, in addition to a much smaller number of journals compared with MEDLINE, is a somewhat longer lag time (approximately 8 months) before a recently published article is included in the data base (explainable at least in part by the fact that new summaries or abstracts are created by Excerpta Medica for each article filed, as opposed to entry by MEDLINE of whatever abstract is provided by the authors themselves in the journal at the time of publication). Additional features of AMA Minet include document delivery, an electronic bulletin board, a health-oriented news clipping service from the Associated Press, computer-assisted instruction provided by the Massachusetts

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General Hospital and a number of AMA-developed data bases oriented particularly toward practicing physicians, including AMA listings of Continuing Medical Education (CME) courses, drug handbooks, and Current Procedure Terminology (CPT) for procedure coding and billing. Recent legal problems between the AMA and GTE (7) concerning medical information systems raise a question about the future of this collaboration.

6. MEDIS. This is a relatively new service offered by Mead Data, vendor of the popular legal data base, LEXIS, and the general information data base, NEXIS. The full MEDLINE citations are available only since 1981; there are also subspecialty files including one in cardiology. Of interest are full text holdings of about 40 medical journals including only *American Journal of Cardiology* and *Progress in Cardiovascular Diseases* in the cardiology field. Six textbooks, none in cardiology, the NCI PDQ files, various pharamacologic and drug information files and a number of administrative documents (for example, Joint Commission on Hospital Accreditation Manual, Federal Register) are also available in full text. MEDIS appears considerably more expensive than its competitors, with a $200 initial subscription charge, a $50 monthly charge (not a minimum), a $30 hourly charge and a $3 charge per MEDLINE search. There is a 30% discount of the hourly rate for searches made between 7 PM and 7 AM. The advantage of MEDIS, though, is the breadth of nonmedical information available through NEXIS and LEXIS (the latter at extra charge). NEXIS contains the full text of the *New York Times,* the *Washington Post, Time, Business Week* and more than 100 other newspapers, magazines and newsletters. Also available are the major wire services (Associated Press, and so on) and much financial, scientific and technical information including recently published patents. MEDIS is available basically 24 hours daily, except for 10 PM Saturday to 6 AM Sunday.

7. Mini-MEDLINE. This is a slimmer version of the full MEDLINE, developed at Georgetown and available in a number of libraries. A small number of journals deemed most important are included (as opposed to the more than 3,000 journals in *Index Medicus*). At Cornell, mini-MEDLINE currently includes 300 journals; *Circulation, American Journal of Cardiology, Journal of the American College of Cardiology, American Heart Journal, British Heart Journal* are all included; *European Journal of Cardiology* and *International Journal of Cardiology* are the only journals of substantial importance to cardiologists that are *not* included. Mini-MEDLINE is exceedingly simple to use, requiring literally only a few minutes (<10 for most people), of demonstration or self-instruction. The mini-MEDLINE data base is only a bit further behind than MEDLINE itself with libraries receiving monthly data base updates on tape. The fact that the user is accessing the library's own computer with its taped mini-MEDLINE files means that the National Library of Medicine computers are not needed day to day, and there are no telecommunications charges; the only charges are for leasing access to MEDLINE, creating the slimmer file and running the library's in-house computer system. At Cornell, the low operating cost of mini-MEDLINE plus grant support has made it possible to allow free access to all users (indeed the library's card catalog is on the same computer system and so users have multiple incentives to use the in-house computer system).

This system is not available to individuals but is mentioned here because users of cooperating medical libraries often receive their first introduction to computer literature searches in general and to the MEDLINE files in particular through mini-MEDLINE.

Specialized Software Programs

These programs, purchased by the user, interact between the user and the access services described. One of their features is that they make searches simpler, by providing, for example, automatic telephone dialing, proper sign-in by password and translation of "user friendly," frequently natural language commands into the often highly idiosyncratic language of the various data bases.

For example, to search by author in MEDLINE requires the exact keystrokes, Scheidt S. A BRS search requires Scheidt-S, with no space, but with a dash. For subject headings, unless certain qualifying instructions are given ahead of time, MEDLINE will only retrieve according to the exact MeSH subject heading. Specialized software programs assume far less specialized knowledge of commands, protocols, subject headings, and so on, on the part of the user, and automatically convert inexperienced queries either off-line or on-line (the former saving money, of course) into language understood by the particular access service subscribed to. Add-on software programs make it simple to subscribe to several data bases (for example, NLM plus BRS plus DIALOG) and to use the software to search several data bases with one set of natural language instructions.

Finally, most of the add-on software programs add the capability of creating a personal file, indexed according to personal needs, that can be transferred automatically from the MEDLINE data base and saved in one's own computer (so-called downloading). Many of these software programs can be used for a myriad of other applications, including correspondence, research files and reports and patient records.

Sci-Mate, Searchmaster and *In Search* are three currently available software programs. It is not clear that these software programs make searches either simpler or cheaper (5), and they do cost several hundred dollars each for initial purchase.

Conclusions

Medical literature searches are now easily made by health professionals with minimal training and relatively modest initial investment and operating costs. A terminal or personal computer with modest communications software, modem and access to a commercial or noncommercial search service is all that is needed. On-line costs of various systems range from about $20 to $30 an hour of access time with the average search requiring perhaps 5 to 15 minutes of computer time. However, there are many potential pitfalls that can greatly increase the expense of literature searching: fixed fees or minimum charges that with some systems may reach $50 monthly; additional charges per search or per citation; purchase price of add-on software packages that ease searches; and, often hidden but no less important, the time of the user—time spent in searching *and* time spent in sifting through the output—which may be voluminous and largely nonrelevant. Adding everything together, the Cornell Medical Library's charge of $15 per literature search request seems a good estimate of the true cost, and for that one receives the benefits of having a highly experienced searcher and of not spending one's own time searching.

On the other hand, doing one's own literature searching has obvious benefits in terms of the ability to find precisely what one seeks, once the search technique is mastered. Convenience and useful additional services such as access to other medical and nonmedical data bases may also be of interest.

The capabilities exist. Individual physicians, evaluating their individual needs and styles of practice or research, will reach different decisions as to whether or not personal computer literature searching is indispensable to them.

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