Clinical problem solving by computer

ABSTRACT—Computer access to the medical literature has become more convenient than ever with MEDLINE and other bibliographical databases available on CD-ROM. The benefits of literature searching by computer include improvements in the quality of medical decision making and cost effectiveness of patient care. However, the results obtained by physicians with amateur searching skills are often inferior to those obtained through the traditional service mediated by a skilled librarian. To ensure that future physicians develop the skills necessary for effective use of the medical literature, it is essential to provide training in literature searching by computer at medical school.

Up-to-date knowledge about patient prognosis, the value of diagnostic tests and the effects of treatments is essential to enable physicians to provide optimal care for their patients [1]. Delay in the dissemination of relevant knowledge could often be avoided by more effective use of the medical literature. For example, physicians caring for diabetic patients were unaware of the efficacy of photocoagulation for diabetic retinopathy some 18 months after the publication of a definitive report establishing its value [2].

Physicians cannot memorise all the information they need, and medical knowledge changes so rapidly that much of what they learn is eventually obsolete [3]. The past century has seen impressive growth in medical science. The number of articles covered by Index Medicus, the printed guide to the world’s medical literature produced by the National Library of Medicine (NLM), has grown from 20,000 to over 300,000 per year [4]. Although it continues to serve a useful purpose as a means of locating relevant information, physicians need more efficient access to the medical literature to keep up to date with new developments.

Articles dealing with a specific topic of interest can be located much more efficiently with the aid of a computer system than by manual searching. Instead of looking up the relevant subject headings one at a time in a printed index, users can combine any number of subject headings in a single computer search. MEDLINE, the NLM’s major bibliographical database, contains references to some seven million articles published in the biomedical literature since 1966 and is searched more than 18,000 times a day [5]. Each reference consists of the title of the article, the names of the authors, and full publication details including the title of the journal, volume number, year of publication, and first and last pages. For most articles, an English abstract is also available.

A thesaurus known as Medical Subject Headings (MeSH), originally developed as the standard vocabulary for Index Medicus, is used in MEDLINE to index articles from 3,500 journals published throughout the world. MeSH terms describing the concepts contained in an article are assigned to the article by human indexers. Any combination of the 16,000 terms in the MeSH thesaurus can be used to retrieve references that are relevant to a specific topic. References can also be retrieved by author name or on the basis of text words appearing in the title or abstract of an article, though a limitation of the latter approach is that a word used in a search query may be spelt differently, used in a different sense, or replaced by a synonym in a relevant article.

The Rochester study [6] has shown that knowledge of the medical literature has a major impact on the quality of decision making in diagnosis (29%), choice of tests (51%) and choice of drugs (45%). It can also reduce the number of unnecessary hospital admissions (12%) and length of stay in hospital (19%). Another recent study, by Klein and Ross, has shown that in 70% of cases, literature searching by computer can reduce hospital expenses [7].

The recent emergence of evidence-based medicine as a new paradigm for the practice of medicine [1,8,9] is another reason for the growing importance of literature searching skills for physicians. Its proponents argue that more effective use should be made of the medical literature to guide problem solving in everyday clinical practice.

On-line access to MEDLINE

In the past, access to MEDLINE required the assistance of a search intermediary (a librarian with specialist training in the use of on-line bibliographical databases) to enter a search query on behalf of the end user (the physician) at a computer terminal located in a medical library. Since the introduction of user-friendly access to MEDLINE in 1986, there has been a seven-fold increase in its independent use by physicians engaged in direct patient care [4]. Search systems that enable users with little or no formal training to conduct MEDLINE searches without assistance from a librarian include NLM’s Grateful Med [3–5], Beth Israel Hospital’s PaperChase [10–13], and Ovid Technologies’ OVID [14].

On-line access to MEDLINE from a personal com-
computer with appropriate communications software, linked by a modem to a telephone line, is possible by various routes. The British Medical Association (BMA) library runs a 24-hour MEDLINE service for BMA members which up to 20 users can access simultaneously. There is no charge for access apart from normal telephone charges. A password is needed and can be obtained by application to the library. The search system used to conduct searches is OVID. The communications software recommended for access to the service is Norton pcAnywhere from Symantec. Members should type IBMVID when they log on using this software, or VTOVID if using other communications software [14].

As an alternative to dialling in from home, BMA members can access the association's on-line MEDLINE service on the Internet [15], to which desktop computers in many universities and medical libraries are connected. Another method of Internet access to MEDLINE is NLM's Grateful Med service [4,5]. Available for the IBM PC and compatibles and for the Apple Macintosh, the Grateful Med program must be installed on the user's own computer and is sold in the US by the National Technical Information Service for $29.95. The package includes a user guide, an interactive tutorial, and an application form for the user code and password required for access to MEDLINE.

In addition to MEDLINE, registered Grateful Med users can access several of NLM's other databases including AIDSLine (AIDS information onLINE), CANCERlit (CANCER LITERATURE), HEALTH (HEALTH planning and administration), SDILINE (Selective Dissemination of Information onLINE) and TOXLINE (TOXicology Information onLINE). The hourly rate for access to MEDLINE and most of the other available databases is about $18.

Providers of on-line access to MEDLINE may offer Selective Dissemination of Information (SDI) as an additional service which physicians can use to ensure they are regularly notified about new journal articles of particular relevance to their interests. An appropriate search query is run on a regular basis and the results forwarded to the physician. Alternatively, SDI is available on a self-service basis to Grateful Med users through regular on-line access to SDILINE, which contains references from the most recent complete month in the MEDLINE database [5].

CD-ROM access to MEDLINE

Today, computer access to the medical literature is more convenient than ever, with recent years of MEDLINE and other bibliographical databases available on CD-ROM (compact disc read only memory). A CD-ROM disc [16] resembles the familiar audio compact disc widely used with domestic hi-fi equipment and can store a large volume of textual information (in addition to digital images, audio and video for multimedia applications). Information stored on it can be accessed directly by a personal computer equipped with a CD-ROM drive and appropriate software. Personal computers with built-in CD-ROM drives are now widely available. Alternatively, a separate CD-ROM drive can be connected to an existing personal computer.

Publishers of MEDLINE on CD-ROM include Knight-Ridder Information (formerly Dialog Information Services), Ovid Technologies (formerly CDP Technologies), and SilverPlatter Information. Factors to consider in choosing from the available titles include ease of use of the search system, number of years of the MEDLINE database covered, and frequency of updating included in the annual subscription. Typically, a single CD-ROM disc can accommodate one or two years of the MEDLINE database. Alternatively, some titles offer focused coverage of a selected area of specialisation such as cardiology, dermatology or paediatrics. Because only references (including abstracts) to articles published in selected journals are included in these specialised databases, several years of references can be accommodated on a single disc.

MEDLINE titles available from Ovid Technologies, for example, include the five or ten most recent years and the complete database (1966 to date). A minimum of three CD-ROM drives is recommended for the latter option. The ten-year database is provided as a collection of eight CD-ROM discs and the annual subscription of around £1,000 for a stand-alone CD-ROM workstation includes the OVID search system and monthly updates of MEDLINE coverage. Subscription rates for multiple-user network access are considerably higher.

In the OVID search system, all the major functions can be accessed by pull-down menus, or buttons, so that users with only a basic idea of search concepts can easily construct useful queries. At the start of a session, users are invited to select a database segment to be searched (eg MEDLINE 1993–94 from a menu, and then asked to insert the CD-ROM disc containing the selected database segment. At this stage the search system is ready to accept queries.

The simplest query consists of a single word or phrase describing the topic of interest. Users can enter an appropriate MeSH term, if known, or describe the topic in their own words. The phrase entered by the user will be mapped to a valid subject heading from the MeSH thesaurus, if possible, in a few seconds. For example, heart attack will be mapped to myocardial infarction. If the computer fails to recognise the phrase entered by the user, it may be necessary to try a few synonyms until it gets the message, or the reason may be a typing or spelling error. For example, pseudogout will be mapped to chondrocalcinosis but pseudo-gout will not be recognised.

The user is now invited to select from the subject heading returned by the mapping process, one that is more specific, and one that is more general. Another
option is to narrow the focus of the search by selecting one or more of the subheadings associated with the subject heading in the MeSH thesaurus, such as complications or aetiology of a disease.

The selected subject heading is used to search the database segment. The user is told the number of references retrieved and invited to enter another word or phrase describing the topic of interest. Alternatively, the user can view the titles or abstracts of articles located by the first query or have the abstracts printed out. As well as searching by subject, the user can search for a text word which appears in the title or abstract of an article.

Queries previously entered by the user in the current session (and the numbers of references retrieved) are displayed on the screen. The user can select two queries (using the mouse) and logically combine them to form a new query by choosing a logical operator such as AND/OR from a menu. A query formed using AND will retrieve only references to articles which match both of the original queries, so a substantial reduction in the number of references retrieved can usually be expected.

The aim of searching is to find references to articles that are most relevant to the topic of interest to the user. Obtaining the best results usually involves a process of trial and error, although planning the search strategy in advance will help to save time and minimise frustration. While simple queries based on a single subject heading are likely to retrieve too many articles, a combination of two or three such queries will often reduce the number of references retrieved to a manageable size. One way of deciding which additional subject headings to include is to examine the MeSH terms used to index references that appear particularly relevant among those retrieved by a previous query.

If too many references are retrieved even when all relevant subject headings have been incorporated in a query, there are several other ways of limiting the search to articles that are most likely to be useful. For example, the search can be limited to randomised controlled trials (RCTs), studies involving human subjects, or studies involving subjects of a specified age or sex. The user can also limit the search to articles written in English, published within a specified range of years, or in which the subject of main interest to the user is the major focus. Another option is to limit the search to journals that are held locally, provided these have been identified by the system administrator.

OVID features a powerful command syntax which experienced users can use as another way to enter queries. Another useful feature is a graphical display of the hierarchical relationships between terms in the MeSH thesaurus, from which terms can be selected for use in queries.

Given its convenience, ease of use, and relatively low cost, CD-ROM offers an attractive method of access to MEDLINE for physicians wishing to develop literature searching skills. The user can take time to try different search strategies without having to worry about the mounting cost of on-line connection to a remote database. One disadvantage in comparison with on-line access is that if a workstation is equipped with only a single CD-ROM disc drive, the user will be able to access only one or two years of the MEDLINE database at a time.

### Randomised controlled trials

The most conclusive evidence to support clinical decision-making comes from RCTs, which account for only a small fraction of all published articles. However, studies of the effectiveness of literature searching by computer show that MEDLINE searching is not yet sufficiently sensitive to be recommended as a complete strategy for keeping up to date with the literature on RCTs. For example, the sensitivity of a MEDLINE search designed by a medical librarian to detect RCTs concerning the prevention and treatment of diseases of the newborn was only 53% [17].

The sensitivity of a similar search prepared by two physicians with amateur literature searching skills was even lower at 34%. Among 53 RCTs detected by a manual search, 21 were not identified by either of the MEDLINE searches. Seventeen of these were missed because of the indexer’s failure to assign sufficiently stringent methodological terms. There have been other reports of the low sensitivity of computer searches for RCTs and the phenomenon is not unique to the perinatal literature [18,19].

### The Cochrane Database of Systematic Reviews

More than twenty years ago, Archie Cochrane drew attention to the need for systematic reviews of all relevant RCTs as a basis for more informed decisions about health care [20]. The Cochrane Collaboration, an international network of individuals and institutions committed to preparing, maintaining and disseminating systematic reviews of the effects of health care, has evolved in response to this challenge [21]. Founded in England in 1992, it now has centres in Australia, Canada, Denmark, France, Italy, the Netherlands and the US as well as the UK.

Reviews prepared by the Collaboration, and protocols for reviews in progress, are maintained in a database called the Cochrane Database of Systematic Reviews (CDSR). Distributed on CD-ROM or computer disk and on the Internet, the database is updated and amended as new evidence becomes available and errors are identified, and includes contact details for review authors and editors to allow critical feedback about the reviews [22]. Each review in the CDSR takes the form of a structured report with five main sections: introduction/statement of objectives, materials and methods, results and discussion.

Full citations are given of all studies included in the review (and relevant information for assessment of
their methodological quality) and of studies that the reviewers decided not to include (with reasons for their exclusion). The results of the review are presented in tabular form, with statistical meta-analyses where appropriate (and possible), and contact details for relevant unpublished and ongoing trials. The CDSR is available from Update Software, Oxford, as part of an electronic publication called The Cochrane Library, which is distributed by subscription on CDROM or disk, updated quarterly.

Other biomedical databases

Although MEDLINE is the most widely used of all medical databases, its coverage of the biomedical literature is limited to journals that are included in the Index Medicus and does not include published conference proceedings, books or reports. Other major databases that contain biomedical information include BIOSIS Previews, EMBASE and the Science Citation Index [4, 23]. Each has a different emphasis, with only a 37% overlap in coverage among the four databases including MEDLINE [23].

The Science Citation Index (SCI) is one of three printed citation indexes containing details of articles from over 7,000 journals worldwide, and produced by the Institute for Scientific Information (ISI). Not only articles but also the references they contain are indexed in SCI, which makes it particularly useful for identifying articles that are potentially related to one another because they cite the same reference and for tracing subsequent work done on a subject [4]. Online access to SCI and other ISI databases is available free to staff and registered students of academic institutions subscribing to BIDS ISI, a service operated by Bath Information and Data Service (BIDS).

Covering over 3,500 journals worldwide, EMBASE is a major biomedical and pharmaceutical database produced by Excerpta Medica, a division of Elsevier Science. Its particular strengths include drug research, pharmacology, toxicology and its coverage of European journals. One method of on-line access to the database is BIDS EMBASE, a service offered on a site-licence basis to academic institutions by BIDS. EMBASE titles available on CD-ROM include the complete database from 1980 or 1988 to date and subset databases that offer focused coverage of a selected area of specialisation such as drugs and pharmacology or psychiatry.

BIOSIS Previews, produced by Biosciences Information Service, is the on-line counterpart to Biological Abstracts [4]. It covers the worldwide literature on research in the life sciences, including 9,000 scientific journals as well as books, reports and conference proceedings.

Discussion

Current methods of literature searching by computer are easily accessible and relatively easy to use. The search systems now available are sufficiently user-friendly to enable the most inexperienced user to perform simple searches. However, the results obtained by end-user searching may be inferior to those obtained through the traditional service mediated by a skilled librarian [3, 4, 17, 24]. To ensure that the physicians of the future develop the skills necessary for effective use of the medical literature, training in literature searching by computer should be provided at medical school [25-27].

Literature searching skills are currently taught in less than 40% of European medical schools [28], although studies by Emanuele [29] have shown that training at medical school is a key factor influencing frequency of use and continued use of MEDLINE. This is confirmed in a study by Wallingford and others, who found evidence that use increases as familiarity increases [30].

Given the potential improvements in the quality of medical decision-making and cost effectiveness of patient care [6, 7], the cost of literature searching should not be allowed to deter its use. It has been suggested that charges for searches, like those for blood counts, chest films and computed tomographic scans,

Addresses and telephone numbers

Bath Information and Data Service, University of Bath, Bath BA2 7AY. Tel: 01225 826074.
BMA Library Medline Service. Tel: 0171 383 6224.
BMJ Publishing Group, BMA House, Tavistock Square, London WC1H 9JR. Tel: 0171 383 6185.
National Technical Information Service, US Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161, US. Tel: (+1)(703)487-4650.
Ovid Technologies Ltd, 1 Lamington Street, London W6 OHU. Tel: 0181 748 3777.
SilverPlatter Information, 10 Barley Mow Passage, Chiswick, London W4 4PH. Tel: 0181 995 8242.
Symantec Ltd, St Cloud's Gate, St Cloud Way, Maidenhead, Berkshire, SL6 8AW. Tel: 01628 592 222.
UK Cochrane Centre, Summertown Pavilion, Middle Way, Oxford OX2 7LG. Tel: 01865 516300.
UK/Knight-Ridder Information Ltd, Haymarket House, 1 Oxendon Street, London SW1Y 4EE. Tel: 0171 930 7646.
Update Software, Summertown Pavilion, Middle Way, Oxford OX2 7LG. Tel: 01865 513902.
should be passed on to the patient's health insurers [31]. This would seem reasonable as literature searches are often quicker and cheaper than other tests ordered in the clinical setting, and sometimes more useful.

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