Computerised protocols for laboratory investigation and their effect on use of medical time and resources

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Abstract

Aims: To devise a computerised management system protocol which not only proposes the laboratory investigations to be performed on each patient but also performs related clinical functions.

Methods: The system was designed by senior members of staff. The protocols defined all laboratory investigations including haematology, biochemistry, immunology and cross-matching, and included static and dynamic rules. Patients can be changed to different or additional protocols, as required; likewise proposed tests can be deleted or added. The software is written in MUMPS and runs on a 386 PC running MSM MUMPS under MSDOS.

Results: The number of clinical chemistry tests requested per patient per day fell by 9.5% ($p < 0.01$) for transplant recipients and by 28.8% ($p < 0.01$) for non-transplant recipients. The average time spent by junior medical staff requesting laboratory investigations and enquiring about results fell from 10 minutes per patient per day to 4.1 minutes ($p < 0.001$).

Conclusions: The introduction of this system in no way abrogates clinicians' responsibility for the management of patients, because all proposed investigations must be confirmed or modified by the authorising doctor. The system allows for the audit of requesting patterns and subsequent improvement in protocols by recording any alterations made to the proposed investigations. Significant benefits in terms of better use of house officer time and medical resources were also achieved.

House officers spend a great deal of their working hours performing routine but essential tasks which are secondary to their main function of looking after patients, such as writing request forms and obtaining and assessing results.

Clinicians use protocols to define diagnostic procedures and investigations in the management of patients in different circumstances. Such protocols are often informal, incomplete, and may be unwritten, and are usually drawn up by experienced clinicians but generally implemented by more junior staff. Deviations from protocols occur for several reasons: first the patient's clinical condition may change unexpectedly, requiring emergency investiga-

tion. Second, the protocol may be inadequate and may not deal with all aspects of the patient's condition. Changing situations, such as the introduction of new drugs, may render a protocol out of date. Often, however, deviations from protocols are due to inadequate communication by senior medical staff, lack of understanding by junior staff, and a concern that important tests should not be omitted.

Methods

PROTOCOLS

Investigation protocols were designed by senior members of the Liver Unit to be applied to all patients admitted to the Unit. The protocols define all laboratory investigations including haematology, biochemistry, immunology, microbiology and cross-matching, and contain both static rules (such as liver function tests to be performed for a patient for the first 14 days after transplantation) and dynamic rules (so that, for example, liver function tests will be requested on day 15 if the serum bilirubin on day 14 is greater than 50 $\mu\text{mol/l}$). Static rules can be applied to all pathology disciplines, but the automatic application of dynamic rules is currently only possible for clinical chemistry and haematology in this hospital where the laboratory computers are directly linked to the system. Patient management falls broadly into seven basic investigation protocols and patients are allocated, on admission to the Unit, to one (or more) of these. Patients may be changed to different (or additional) protocols as required by their clinical condition.

During the day the results of investigations are received by the system, and at any time, but normally at about 1700 hours, the house officer reviews both the results and the investigations proposed for each patient for the following day. Proposed tests can be deleted and additional tests added. Request labels, designed in conjunction with the laboratories and phlebotomists, are generated automatically. Details printed include the patient's name, registration number, date of birth, diagnosis, ward and investigations required, together with the type of specimen tube to be used and whether the sample represents a biohazard. An additional label for attachment to the specimen tube is also generated. No additional writing or signature is required, because authorisation is conferred and recorded by the house officer's preview and possible amendment of the proposed tests. Audit of the system flows from its internal recording of tests proposed by protocols but deleted by the house

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Table 1 Effect of protocol application on clinical chemistry investigations

	Before	After	% Change
<i>Transplant recipients (excluding trial test)</i>			
No of patients	32	16	
No of tests	8503	2835	
No of patient days	871	321	
Test per patient day	9.76	8.83	-9.5*
<i>Non-transplant recipients</i>			
No of patients	81	93	
No of tests	6332	4198	
No of patient days	758	706	
Test per patient day	8.35	5.95	-28.8*

* $p < 0.01$ (t-test)

officer, of tests manually added and of unsolicited results received—that is, requests made without using the system.

THE COMPUTER SYSTEM

The computer system and the generalised software in which the investigation protocols are expressed have been described in detail elsewhere.^{1,2} The software is written in MUMPS and runs on a 386 PC running MSM MUMPS under MSDOS linked to laboratory computer systems and to the hospital PAS.

HOUSE OFFICER TIME

House officers were asked to fill in diaries for three weeks before and three weeks after implementation of the system, recording the number of minutes spent writing request forms and obtaining results and the times at which these activities were undertaken.

Results

The investigation management system was introduced on 1 January, 1991. The junior house staff changed on 31 January. During the three months of the evaluation period, 14% of the patients admitted received liver transplantations, 32% were admitted for investigation, 7% were admitted with fulminant hepatic failure and 46% for other reasons. As a comparison we studied a similar period of time between October and December 1990 during which the percentages of patients in each of these categories were 15%, 35%, 8% and 42%, respectively. The effects of protocol management on levels of haematology investigation were not evaluated because data for the comparative study period could not be obtained from the laboratory's computer system.

Table 2 Average daily time spent by house officers requesting laboratory tests and enquiring about specimens and results

	Before	After
Average daily number of patients on unit	13	17
a) Requesting (form filling/label writing)		
Time spent (minutes):		
Between 8 am and 8 pm	51 (0-122)	27 (0-60)
Between 8 pm and 8 am	38 (0-110)	12 (0-60)
Total time spent (minutes)	89 (10-175)	39 (15-60)
Average time per patient (minutes)	6.8 (0.8-14.0)	2.3 (1.2-3.3)*
b) Specimen/result enquiries		
Total time spent (minutes)	41 (2-89)	30 (10-60)
Average time per patient (minutes)	3.2 (0.2-6.4)	1.8 (0.6-3.3)
Grand total (minutes)	130 (12-236)	69 (40-115)
Grand total per patient (minutes)	10.0 (0.9-18.2)	4.1 (2.4-6.3)*

Values given in parentheses are ranges

* $p < 0.001$ (Mann-Whitney test)

EFFECT OF COMPUTERISED PROTOCOL MANAGEMENT ON PATHOLOGY REQUESTING

In the study period before the system was introduced there were 32 liver transplant recipients compared with 16 in the period after implementation. Overall, the numbers of clinical chemistry tests measured for each transplant recipient were similar before and after the system was introduced. However, coincident with the introduction of the system a prospective study comparing FK506 with cyclosporin was begun. The study generates extra tests, and removal of these from the analysis showed a 9.5% reduction in the number of analyses requested per patient day after introduction of the system (table 1). There was no significant difference in inpatient stay or outcome.

In non-transplant recipients there was a 28.8% reduction in the number of tests requested per patient per day. There was no significant change in the duration of inpatient stay and there were no significant differences in the clinical diagnoses of the patients in the two periods of study. The customary increase in laboratory requesting immediately following the introduction of new house officers was not observed.

EFFECT OF COMPUTERISED PROTOCOL MANAGEMENT ON HOUSE OFFICER WORKING PRACTICES

The introduction of the protocol management system resulted in a significant reduction in the amount of time spent by house officers in filling out request forms and label writing (table 2) and in enquiring about specimens and results.

Discussion

The preliminary results of this initial trial have shown that this approach can be of substantial benefit in reducing the amount of time spent by house officers on secretarial matters, and perhaps more importantly this has been associated with a reduction in the amount of late night work. Some saving in medical staff time could be anticipated from experience in countries where non rulebased ward ordering systems provide streamlined requesting facilities but such systems do not provide dynamic investigation management which we have found to relieve junior medical staff of time consuming collating and listing activities. Patients are investigated in a logical and predefined way and investigation protocols may be readily assessed and modified. There has been an additional benefit in that the total number of investigations requested has been significantly reduced. However, no account is taken of cost, and although the number of tests requested has been reduced inappropriate but cheap analyses might have decreased with some increase in appropriate but more expensive ones.

Audit is rightly achieving increasing importance and the Audit Commission has recently highlighted the need for improvement in the use of laboratory services.³ Overuse of labor-

atory facilities has been attributed to a number of factors, not least the practice of defensive ordering by junior medical staff, possibly to appease senior colleagues,⁴ and to allay fears of possible accusations of malpractice. Many strategies have been proposed to improve laboratory use. These include the design of problem orientated request forms,⁵ the use of financial rewards for junior staff,⁶ comprehensive feedback to senior staff of pathology requesting patterns and costs,⁷ chart review with emphasis on its educational role^{8,9} and the introduction of clinical guidelines and protocols for investigation.^{10,11} Such strategies have not been uniformly successful. Attempts to alter the patterns of requesting must involve the expertise of the more senior staff, but this must directly modify the behaviour of those who are requesting the tests. Exclusion of junior staff from feedback on pathology requesting is unsuccessful.⁷ Laboratory costs must be balanced against other measures of patient care. It is important that any intervention designed to modify requesting behaviour must be sustained or frequently reinforced to maintain the desired effect.^{6,10} Ongoing participation of junior staff needs to be encouraged and can only be achieved if they perceive that there is an advantage, not only to their patients, but also to themselves.

Implementation of computer assisted protocol management has, by radically altering the interface between the requester and the laboratory, specifically addressed some problems encountered in rationalising the use of laboratory resources. The introduction of locally agreed requesting protocols addresses problems of medical and local pathology audit and has shifted the burden of protocol planning from junior to senior staff and the clerical load to the computer. At no level can the medical staff abrogate their responsibilities because it is their duty to ensure that appropriate tests are requested and the information gained acted on. Thus there is no threat to clinical freedom.

Further studies are in hand to quantify

effects of refinements to investigation protocols and to examine changes in pathology testing in terms of volume and cost. The system is currently being extended to include outpatient clinics and drug prescribing.

It is clearly important that the system we have developed should be evaluated in other centres and in other disciplines. Nevertheless, it is felt that this initial trial has validated our approach and has shown that, in an albeit limited context, this approach works effectively, is associated with a reduction in laboratory investigations, reduces the time spent by junior staff on areas peripheral to their main role, and permits audit both within units and between units.

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- 1 Peters M, Clark IR, Parekh J, *et al.* Automatic application of rule-based decision support—a specialist unit investigation manager. In: Richard B, ed. *Current perspectives in healthcare computing*. 1991.
- 2 McCauley BA, Parekh J, Clark IR. A MUMPS application of rule based processing. In: Dayhoff RE ed. *Proceedings of the MUMPS Users' Group Meeting 1991*. College Park, Maryland: MUMPS Users Group, 1991.
- 3 The Pathology Services. A Management Review. The Audit Commission for local authorities in The National Health Service of England and Wales. London. HMSO, 1990.
- 4 Hardison J E. To be complete. *N Engl J Med* 1979;300:193-4.
- 5 Wong ET, McCarron MM, Shaw ST. Ordering of laboratory tests in a teaching hospital. *JAMA* 1983; 249:3076-80.
- 6 Martin AR, Wolf MA, Thibodeau LA, Dzau V, Braunwald E. A trial of two strategies to modify the test ordering behaviour of medical residents. *N Engl J Med* 1980;303:1330-6.
- 7 Grivell AR, Forgie HJ, Fraser CG, Berry MN. Effect of feedback to clinical staff of information on clinical biochemistry requesting patterns. *Clin Chem* 1981;27:1717-20.
- 8 Heath DA. Medical audit in general medicine. *Roy Coll Phys Lond* 1981;15:197-9.
- 9 Griner PF and the medical house staff. Use of laboratory tests in a teaching hospital: long-term trends. *Ann Intern Med* 1979;90:243-8.
- 10 Young DW. An aid to reducing unnecessary investigations. *Br Med J* 1980;281:1610-1.
- 11 Fowkes FGR, Hall R, Jones JH, *et al.* Trial of strategy for reducing the use of laboratory tests. *Br Med J* 1986;292:883-5.