Data handling and reporting for microbiology specimens with a small laboratory computer system

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SUMMARY A small laboratory computer system designed for general application in chemistry, haematology, and urinalysis has been adapted for the bacteriology section of the laboratory using the same available programming routines. Specimens are requisitioned according to predetermined common site codes, with both preliminary and final reporting allowed for where desired. Sensitivity data are also appended and entered where required, even for different organisms in the same culture.

Many small computer systems in use today are solely devoted to laboratory use. Other computerised laboratories are often part of an overall hospital-based system with much larger memory and peripheral capacity that may or may not be totally accessible at all times. Our system is of the former type with limited capacity. Automated chemistry and haematology instruments are on-line for instant, complete data acquisition of up to 20 chemistry and 7 haematology tests, while several cathode ray tube (CRT) terminals are available for manual entry of data plus other clerical and housekeeping routines such as maintaining patient census and logging-in of specimens.

The manual data entry routine is well-suited for recording numerical results from tests performed manually. From each work-station, these data are entered in any order, by specimen number, with patient verification at each entry. Alpha-numeric results such as urinalysis are entered similarly, but the actual entry is chosen by the technologist from a

predetermined list of permissible answers displayed on the screen for each test or subtest (Table 1). In either type of entry, numeric or alpha-numeric, the technologist can always append a pertinent note for any specimen if needed.

This manual entry procedure can be very tedious for high volumes of routine samples such as urinalysis or differentials which have many subtests. Ideally, the entry of non-automated tests can be semi-automated through the use of punch card or mark sense readers but this adds an expense that cannot be justified except for the very large laboratory. With a rate of no more than 50 per day of each of these multi-test routines, the task remains feasible with this manual procedure, and the additional hardware is not required.

One difficult area for this limited system, however, is the entry of results from the microbiology section. In particular, the reporting of culture results from a wide variety of specimen sources and the antibiotic sensitivity profiles on the organisms could be difficult with the limitations of the system. Other large systems^{1 2} or dedicated smaller systems^{3 4} could

Accepted for publication 22 October 1980

Table 1 *Routine for manual entry of data*

- (1) Routine is called up by operator at CRT.
- (2) Operator specifies workstation, single test, or several tests for which results are to be entered.
- (3) CRT screen requests "sample number?"
- (4) Operator enters sample number, CRT displays patient name for that sample number for verification.
- (5) CRT also shows test codes for first result to be entered: e.g. WBC (xx.x) if numeric result (with acceptable format) or VDRL: REACT. NONRE. SL. RE. for an alpha-numeric result where VDRL is the test code and the other codes stand for all the possible results for that test. (Up to 32 may be displayed.)
- (6) Operator enters appropriate result.
- (7) CRT then shows the next test code for result entry or, if only one is to be entered for that specimen number, the CRT displays "ENTER NOTE" and a free text entry is permitted if desired.
- (8) After note is entered, or the option by-passed, routine reverts back to Step 3 and continues cycling until all data for tests specified in Step 2 are entered.
- (9) When all data is entered, operator exits routine.

make use of an extensive coded dictionary of organisms in permanent accessible storage for use during operator entry. Or again, a mark sense or punch card system might be used for both culture and sensitivity reporting. Despite the limitations of our small system, a bacteriology reporting routine was devised that still conforms to our alphanumeric entry routine as used for our other kinds of data entry as in haematology, chemistry, and urinalysis.

Material and methods

SYSTEM DESCRIPTION

The computer system in the laboratory for our hospital (about 250 beds), serves all but the blood bank and histopathology sections. It consists of a Digital Equipment Corp Model PDP 8e minicomputer with 32k of core memory and an Iomec Model 2000 disc drive of 2.4 million words of auxiliary memory. The peripherals are from a variety of sources: two 250 lpm (lines per minute) line printers, six TEC, Inc. (Phoenix, Arizona, USA) CRTs with special function keyboards, on-line interfaces to automated chemistry and haematology instruments and a 30 cps (characters per second) printer for monitoring certain preset out-of-range results and for delta check test failure reports. The latter allow for checks on a significant percentage change in a patient test results (numerical only) when compared to a previous result for that test. Each test has its own preset percentage change value assigned to it, which if exceeded will result in a delta check report that requires review by a technologist before the newest result can be released to a report.

PROCEDURE FOR CULTURES

Firstly, a variety of common sites that are cultured, such as blood, urine, sputum, throat, stool, vagina can be "requisitioned" according to a predetermined mnemonic test code for that specific site (Table 2). After the culture procedure, the technologist need only choose to enter whether the result is positive (significant growth observed) or negative (no growth

or normal flora observed only), since the laboratory report will automatically state the source of the specimen according to the originally-assigned code. For less specific specimen sites, in addition to the results of the culture, the technologist must enter the location from which the culture was taken, but may choose from 32 possible choices of body areas displayed on the screen. A urine culture requisition also automatically includes a colony count as a subtest and this numerical result is entered manually, also. The single blood culture request automatically includes the ordering of two subtests. One of these permits the bacteriologist to obtain a 48 h culture report and the second allows for a separate 10 day report to appear. Finally, when a positive culture result is obtained, the organism grown is identified through the entry of a note. The note is carried and matched with the specimen by a set of asterisks in the same column on the laboratory printout. The reports actually produced show both the first (preliminary) and second (final) culture results where both are performed (Figs 1 and 2).

Our laboratory has chosen to do preliminary and final testing on blood cultures and on all testing for acid fast bacillus. However, the same procedure could be set-up for requisitioning and reporting of any and all cultures if so desired.

All reports for bacteriology are cumulative, as in other laboratory areas, in that multiple specimens from either the same date or a series of dates throughout the patient's hospital stay all appear on the report as new results are added (Fig. 2). Each report has the date and time of specimen collection at the top of the column in which the results are printed. The heading also contains "normals" and "units" as a carry-over from other departments such as chemistry and haematology that report numerical results. This is not deleted easily and was left in the bacteriology area of the report. The reports shown are generated by the laboratory printer and then attached to the patient chart on the ward or mailed to the clinic or physician's office.

PROCEDURE FOR SENSITIVITIES

For positive cultures, sensitivity reports must be appended to the patient's open requisition file. This is accomplished through the requisition routine when the culture was first ordered, except now the sensitivity code (SEN1) is added to the specimen number with the positive culture. The SEN1 code includes a complete battery of subtest codes of 18 different antibiotics. For convenience, the complete list is appended to the requisition regardless of the organism or the source of the specimen, and even though no organism is tested against the entire list of antibiotics.

Table 2 *Mnemonic codes for widely-used culture sites*

Code	Site
CULU	Urine
SCUL	Stool
NCUL	Nose
TCUL	Throat
VCUL	Vagina
CCUL	Cervix
PCUL	Sputum
GCUL	Urethra
BCUL	Blood

NAME.....		CUMULATIVE SUMMARY		5/20/80-10:43	ID-1234567
RM	334A	SEX	M	DOB	06/15/1973
		ADM	5/20/80	DR	LANDOWNE
BACTERIOLOGY		NORMALS	UNITS	1/16	1/15
		LOW-HIGH		9:00	8:00
URIN CULTURE		SEN0TE+ NOGROW			
COLONY COUNT		000. 010. TH./ML	100. +	000.	
LAB NOTE:		*****			
		MODERATE E. COLI AND PREDOMINANT FLUORESCENS GROUP.			

Fig.1

NAME.....		CUMULATIVE SUMMARY		1/20/80-11:49	ID-1234567
RM	334A	SEX	M	DOB	06/15/1973
		ADM	5/20/80	DR	LANDOWNE
BACTERIOLOGY		NORMALS	UNITS	1/16	1/15
		LOW-HIGH		9:00	15:00
THROAT CULT.		NFP			
BLOOD CUL 4 8HR		NOGROW		NOGROW	
BLOOD CUL 10DA		PEND.		NOGROW	

Fig.2

NFP = normal flora present.

Note a 10-day blood culture report is still listed as pending.

Fig. 1 Example of urine culture report.

Fig. 2 Example of culture report.

After the actual completion of the sensitivity testing, the codes for each antibiotic are then successively brought up on the CRT as the technologist calls up the specimen number. The technologist then has the option of entering for each antibiotic sub-test whether the cultured organism is resistant (R) or susceptible (S) or of intermediate susceptibility (I) to the antibiotic. If a particular antibiotic was not tested, according to the usual procedures set down by the laboratory for that organism, the letter N is entered for test "not done." In this instance, no line on the report is generated; just as if the test never existed within that specimen number. That is, even though 18 antibiotics' sensitivities may at first have been listed as pending for that culture result, the final report will only show the results for the antibiotics that were actually tested.

The above description applies for the sensitivity testing for a single cultured organism in a specimen. In those instances where more than one organism is

tested, additional sensitivity codes are appended as SEN2, SEN3, etc, in the same manner as SEN1 was appended to the original culture specimen number. Each of the additional sensitivity codes consists of the same coded group of antibiotics but with a different number to coincide with the sensitivity code sequence. For example, SEN1 contains TOB1, CF1, etc, for tobramycin and cephalin while SEN2 contains TOB2, CF2, etc as codes for the same antibiotics in both sensitivities, and so on through SEN4.

Each sensitivity is distinguished one from the other as follows: the same entry options are available for all sub-tests, but the technologist must now use the note entry option for each sensitivity to type in the organism for which that sensitivity profile applies. Thus, if a positive culture is reported out with two organisms found—for example, *E coli* and *Pseudomonas*, and sensitivities were determined for both organisms, one sensitivity report will be followed by the note "*E coli*" and the other followed by the note

NAME	CUMULATIVE SUMMARY		5/20/80-12:21	ID-1234567	PAGE 01
RM 334A	SEX M	DOB 06/15/1973	ADM 5/20/80	DR LANDOWNE	MO00000

BACTERIOLOGY	NORMALS	UNITS	1/20
	LOW-HIGH		16:00

URIN CULTURE	SENOTE+
COLONY COUNT	000. 010. TH./ML 100. +

LAB NOTE: *****
MODERATE E. COLI AND PREDOMINATE PSEUDOMONAS FLUORESCENS GROUP.

SENSITIVITY 1	NORMALS	UNITS	1/20
	LOW-HIGH		16:00

AMPICILLIN	RESIST
CARBENCILLIN	SUSCEP+
CEPHALOTHIN	RESIST
CHLORAMPHEN.	RESIST
GENTAMICIN	SUSCEP+
NALIDIX-ACID	RESIST
NITROFURANT.	RESIST
SULFONAMIDE	RESIST
TETRACYCLINE	RESIST
SULFA+TRIMEP	RESIST
TOBRAMYCIN	SUSCEP+

LAB NOTE: *****
PSEUDOMONAS FLUORESCENS GROUP.

SENSITIVITY 2	NORMALS	UNITS	1/20
	LOW-HIGH		16:00

AMPICILLIN	SUSCEP+
CARBENCILLIN	SUSCEP+
CEPHALOTHIN	SUSCEP+
CHLORAMPHEN.	SUSCEP+
GENTAMICIN	SUSCEP+
NALIDIX-ACID	SUSCEP+
NITROFURANT.	SUSCEP+
SULFONAMIDE	RESIST
TETRACYCLINE	SUSCEP+
SULFA+TRIMEP	SUSCEP+
TOBRAMYCIN	SUSCEP+

LAB NOTE: *****
E. COLI

Fig. 3

Fig. 3 Example of report showing two sensitivity profiles for two organisms found in the same culture.

"Pseudomonas." All sensitivities are printed out in the same column under the specimen originally cultured (Fig. 3).

Discussion

This system has worked very well within the confines of a system designed for basic chemistry, haema-

tology, and urinalysis procedures. No new programming or altered programming was required to institute this simple bacteriology routine within the same system. Naturally, the system does have its shortcomings because of the requirement that organism names have to be typed in from the keyboard and only what is typed and how it is typed appears on the patient's final report or chart.

Spelling errors, unusual abbreviations and style differences between technologists thus offer a problem. The entries are made by the microbiology technologists who performed the work, rather than inexperienced clerical personnel. Any results requiring corrections after entry must be completely deleted and re-entered. The deletion routine adds a statement to the effect that the deletion of the original entry was performed. Although this statement may crowd the reporting area, the correct result is then put in the proper place. The correction routine is seldom used for correcting minor typing errors because of its complexity.

This system has been used successfully for several years and required minimal physician orientation to the manner in which the microbiology results were presented. It has been accepted by them as being a source of high quality complete bacteriology reports integrated with other laboratory data. The capability of the system to produce an interim report for the chart and to match sensitivity with culture results, has been appreciated, also.

Other advantages have been the ability to monitor pending results. The clinician can see from the patient's chart that a culture is in progress since the notation PEND (for pending) appears between the time a specimen has been logged in and finally reported upon. This feature also eliminates the possibility of late reports getting lost, since the pending notation remains there until overwritten by the result.

In addition, all pending specimens can be monitored internally by the microbiology laboratory by using the computer system's capability for extracting on a single printout a list of all specimens for all patients not yet reported upon. This incomplete specimen report covers all outstanding cultures whether one day or two months old, giving the date

of collection, specimen number, patient name, and type of culture for each entry. It is an excellent tool for keeping track of the course of all the work in the microbiology department.

Finally, the cost advantages become evident after only a few months of use of the computer system. The mere act of logging a specimen into the computer results in a charge being made to the patient. A second invoice is not required and the number of lost charges is totally and automatically eliminated. If the specimen is not logged into the computer, the result can never appear on its printed reports, so the log-in procedure is mandatory on both accounts, for invoicing and reporting. The only requirement for charging is to obtain a single complete invoice once daily for all patients for all laboratory work done. This is a simple clerical routine performed by the system itself in about 15 min. By itself, the added collection of test charges, over prior non-computerised charging procedures, paid for the computer in less than two years, more than justifying the cost of purchase.

References

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