Computerised cardiological case notes

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SUMMARY Optical Mark Reader forms have been used by the Cardiac Department at St Thomas's Hospital for six years to store clinical and haemodynamic data by computer. Forms are completed by clinical staff in outpatients and also for those patients undergoing cardiac catheterisation. Three documents are used to record the symptoms and signs at the clinical consultation, the results of relevant investigations, and the important findings at cardiac catheterisation. These documents are fed into a computer and data from them, together with a limited quantity of typed information, are used to produce full clinical reports for our colleagues and the case notes. These reports have saved much secretarial and medical time. A variety of analyses is available for research and management purposes.

Since the mid 1960's numerous efforts have been made to use computer methods for the routine processing of clinical data. For a variety of reasons these have not been wholly successful and, particularly in the United Kingdom, have not been widely used. Perhaps as a consequence, computer resources have been applied instead to activities more peripheral to the clinical consultation, such as patient administration, nursing and laboratory applications and, most successfully of all, to the processing of signals from complicated electronic equipment used in, for example, radiology, chemistry, nuclear medicine, and indeed cardiac catheterisation.

We believe that attempts to computerise the data obtained at a clinical consultation have been hampered by the range and quantity of the information obtainable. Many workers have solved this problem by focusing on a well defined range of disease processes to the exclusion of others: for example peptic ulcers,¹ hypertension,^{2,3} and a variety of applications in which patients themselves use a computer terminal to describe their symptoms.⁴ Despite reducing the problem to more manageable proportions, there still remain difficulties with the computer techniques used to record the data. Solutions usually involve either manuscript or formalised proformae (which are subsequently typed into the computer by secretarial staff)

or direct use of an on-line terminal by the clinician. The former method suffers in the main from delays, transcription errors, and the need for additional staff, while the latter method involves a high capital cost, the need for doctors to acquire typing skills, and often the unacceptable time involved for each conversation.⁵

We present here a system which solves the problem of data input using Optical Mark Reader (OMR) forms on which the clinician directly records the history, physical signs, and the results of most of the more relevant investigations. The system is implemented on a medium scale time sharing computer with a typewriter terminal in the Cardiac Department and shared use of the OMR device.

The system

Three OMR forms are used, one to record the history, physical signs, electrocardiogram, chest radiograph, and echocardiographic findings, a second to record the results of more specialised investigations aimed at the diagnosis of cardiorespiratory disease, and a third to record the techniques and results of cardiac catheterisation.

PATIENT EXAMINATION OMR FORM

This document is used to record information obtained at the consultation in out-patients or on the ward and is filled in at that time by the clinician. The various sections of the form (Fig. 1) record:

—basic patient identification including hospital number

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ST THOMAS HOSPITAL
CARDIAC DEPT. — PATIENT EXAMINATION FORM

Form 28 Issue III 11/80

CS Number: 2043
Patient Name: [redacted]
Referral by: [redacted]
Consultant: [redacted]
Catheter operator: [redacted]

Year 1980: [redacted] Catheter Number: [redacted]

CS NUMBER
For O mark 8 and 2

PAST HISTORY
Effort: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
Syncope: Y, Fatigue: Y
Bronchitis: Y, Oedema: Y
Haemoptysis: Y, Claudication: Y
Cigs/day: 0, 10, 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340, 360, 380, 400, 420, 440, 460, 480, 500, 520, 540, 560, 580, 600, 620, 640, 660, 680, 700, 720, 740, 760, 780, 800, 820, 840, 860, 880, 900, 920, 940, 960, 980, 1000

SYMPTOMS
Effort intolerance: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
Atypical pain: Y, Dint: Y, Pag: Y
Palpitation: Y, Pain: Y, Sep: Y, Pleur: Y
Duration of symptoms: 1 = 15, 2 = 3, 3 = 4, 4 = 5, 5 = 6, 6 = 7, 7 = 8, 8 = 9, 9 = 10, 10 = 11, 11 = 12, 12 = 13, 13 = 14, 14 = 15, 15 = 16, 16 = 17, 17 = 18, 18 = 19, 19 = 20, 20 = 21, 21 = 22, 22 = 23, 23 = 24, 24 = 25, 25 = 26, 26 = 27, 27 = 28, 28 = 29, 29 = 30, 30 = 31, 31 = 32, 32 = 33, 33 = 34, 34 = 35, 35 = 36, 36 = 37, 37 = 38, 38 = 39, 39 = 40, 40 = 41, 41 = 42, 42 = 43, 43 = 44, 44 = 45, 45 = 46, 46 = 47, 47 = 48, 48 = 49, 49 = 50, 50 = 51, 51 = 52, 52 = 53, 53 = 54, 54 = 55, 55 = 56, 56 = 57, 57 = 58, 58 = 59, 59 = 60, 60 = 61, 61 = 62, 62 = 63, 63 = 64, 64 = 65, 65 = 66, 66 = 67, 67 = 68, 68 = 69, 69 = 70, 70 = 71, 71 = 72, 72 = 73, 73 = 74, 74 = 75, 75 = 76, 76 = 77, 77 = 78, 78 = 79, 79 = 80, 80 = 81, 81 = 82, 82 = 83, 83 = 84, 84 = 85, 85 = 86, 86 = 87, 87 = 88, 88 = 89, 89 = 90, 90 = 91, 91 = 92, 92 = 93, 93 = 94, 94 = 95, 95 = 96, 96 = 97, 97 = 98, 98 = 99, 99 = 100

SIGNS
Build: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
Clubbing: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
Periph: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
Cyanosis: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe

PULSE
Rate: 1 = 10, 2 = 20, 3 = 30, 4 = 40, 5 = 50, 6 = 60, 7 = 70, 8 = 80, 9 = 90, 10 = 100, 11 = 110, 12 = 120, 13 = 130, 14 = 140, 15 = 150, 16 = 160, 17 = 170, 18 = 180, 19 = 190, 20 = 200, 21 = 210, 22 = 220, 23 = 230, 24 = 240, 25 = 250, 26 = 260, 27 = 270, 28 = 280, 29 = 290, 30 = 300, 31 = 310, 32 = 320, 33 = 330, 34 = 340, 35 = 350, 36 = 360, 37 = 370, 38 = 380, 39 = 390, 40 = 400, 41 = 410, 42 = 420, 43 = 430, 44 = 440, 45 = 450, 46 = 460, 47 = 470, 48 = 480, 49 = 490, 50 = 500, 51 = 510, 52 = 520, 53 = 530, 54 = 540, 55 = 550, 56 = 560, 57 = 570, 58 = 580, 59 = 590, 60 = 600, 61 = 610, 62 = 620, 63 = 630, 64 = 640, 65 = 650, 66 = 660, 67 = 670, 68 = 680, 69 = 690, 70 = 700, 71 = 710, 72 = 720, 73 = 730, 74 = 740, 75 = 750, 76 = 760, 77 = 770, 78 = 780, 79 = 790, 80 = 800, 81 = 810, 82 = 820, 83 = 830, 84 = 840, 85 = 850, 86 = 860, 87 = 870, 88 = 880, 89 = 890, 90 = 900, 91 = 910, 92 = 920, 93 = 930, 94 = 940, 95 = 950, 96 = 960, 97 = 970, 98 = 980, 99 = 990, 100 = 1000

VENOUS PRESSURE
Height above SA: 1 = 10, 2 = 20, 3 = 30, 4 = 40, 5 = 50, 6 = 60, 7 = 70, 8 = 80, 9 = 90, 10 = 100, 11 = 110, 12 = 120, 13 = 130, 14 = 140, 15 = 150, 16 = 160, 17 = 170, 18 = 180, 19 = 190, 20 = 200, 21 = 210, 22 = 220, 23 = 230, 24 = 240, 25 = 250, 26 = 260, 27 = 270, 28 = 280, 29 = 290, 30 = 300, 31 = 310, 32 = 320, 33 = 330, 34 = 340, 35 = 350, 36 = 360, 37 = 370, 38 = 380, 39 = 390, 40 = 400, 41 = 410, 42 = 420, 43 = 430, 44 = 440, 45 = 450, 46 = 460, 47 = 470, 48 = 480, 49 = 490, 50 = 500, 51 = 510, 52 = 520, 53 = 530, 54 = 540, 55 = 550, 56 = 560, 57 = 570, 58 = 580, 59 = 590, 60 = 600, 61 = 610, 62 = 620, 63 = 630, 64 = 640, 65 = 650, 66 = 660, 67 = 670, 68 = 680, 69 = 690, 70 = 700, 71 = 710, 72 = 720, 73 = 730, 74 = 740, 75 = 750, 76 = 760, 77 = 770, 78 = 780, 79 = 790, 80 = 800, 81 = 810, 82 = 820, 83 = 830, 84 = 840, 85 = 850, 86 = 860, 87 = 870, 88 = 880, 89 = 890, 90 = 900, 91 = 910, 92 = 920, 93 = 930, 94 = 940, 95 = 950, 96 = 960, 97 = 970, 98 = 980, 99 = 990, 100 = 1000

BLOOD PRESSURE
Systolic: 1 = 100, 2 = 110, 3 = 120, 4 = 130, 5 = 140, 6 = 150, 7 = 160, 8 = 170, 9 = 180, 10 = 190, 11 = 200, 12 = 210, 13 = 220, 14 = 230, 15 = 240, 16 = 250, 17 = 260, 18 = 270, 19 = 280, 20 = 290, 21 = 300, 22 = 310, 23 = 320, 24 = 330, 25 = 340, 26 = 350, 27 = 360, 28 = 370, 29 = 380, 30 = 390, 31 = 400, 32 = 410, 33 = 420, 34 = 430, 35 = 440, 36 = 450, 37 = 460, 38 = 470, 39 = 480, 40 = 490, 41 = 500, 42 = 510, 43 = 520, 44 = 530, 45 = 540, 46 = 550, 47 = 560, 48 = 570, 49 = 580, 50 = 590, 51 = 600, 52 = 610, 53 = 620, 54 = 630, 55 = 640, 56 = 650, 57 = 660, 58 = 670, 59 = 680, 60 = 690, 61 = 700, 62 = 710, 63 = 720, 64 = 730, 65 = 740, 66 = 750, 67 = 760, 68 = 770, 69 = 780, 70 = 790, 71 = 800, 72 = 810, 73 = 820, 74 = 830, 75 = 840, 76 = 850, 77 = 860, 78 = 870, 79 = 880, 80 = 890, 81 = 900, 82 = 910, 83 = 920, 84 = 930, 85 = 940, 86 = 950, 87 = 960, 88 = 970, 89 = 980, 90 = 990, 91 = 1000

VENTRICULAR IMPULSE
RV: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
PA: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe

HEART SOUNDS
First: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
Second: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
Third: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
Fourth: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe

MURMURS
Mitral: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
Tricuspid: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
Aortic: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
Pulmonary: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe

PULSE
Trachea: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
Chest: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
Abdomen: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe

RESPIRATION
Trachea: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
Chest: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
Abdomen: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe

ABDOMEN
Free fluid: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
Bowel sounds: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe

CNS
Reflex: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
Tone: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
Power: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
Sensation: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe

FURTHER INVESTIGATIONS
See again in: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe
Disch: 1 = Normal, 2 = Mild, 3 = Moderate, 4 = Severe

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Please use an APPROVED implement Mark calls thus: Cancel errors thus: Referred to:

Fig. 1 The patient examination OMR form.

- important events in the past history
- symptoms of heart disease including effort intolerance
- the complete physical examination including auscultation
- the results of the chest x-ray examination
- the results of electrocardiography
- the results of echocardiography
- a list of proposed further investigations.

The clinician then records, in manuscript and on an

attached sheet (Fig. 2), more comprehensive details of the past history if required, current treatment, and his diagnoses at that time. Diagnoses relevant to cardiovascular disease are numerically coded using a small, easily expandable dictionary; but non-cardiac diagnoses are recorded in text only and are therefore less amenable to subsequent analysis.

The documents are fed into the OMR by a secretary who also types in any extra information relevant to each record. If error free, the computer record is

ST. THOMAS' HOSPITAL
DEPARTMENT OF CARDIOLOGY

DATE:

NAME: *Frederick [redacted]*

CB No.: *204 [redacted]*

ADDRESS:

D.O.B.:

SOURCE OF REFERRAL:

CATH. No.:

G.P.:

DIAGNOSIS: *128, 129*

PAST HISTORY: *1940 Polio affecting legs
1940 Appendicitis - peritonitis
1968 M.I.
1971, 1973, 1975, 1977 Paroxysmal tachycardia requiring admission
to hospital 1980 Cholecystectomy 1981 Dr
hypercholesterolaemia discovered 1966 - hypothyroidism
diagnosed. feelings of impending disaster
FAMILY HISTORY: *brother has had M.I.**

TREATMENT:
*L. Thyroxine 0.15 mg 1 day
In the past has had Clophemate, Betacardone 8mg 1 day*

SUFFIX:

Fig. 2 The manuscript appendage to the OMR form in Fig. 1.

added to its files, merging it with any existing information for that patient. If there are no outstanding investigations other than blood tests, a full report is then printed on the typewriter terminal in the cardiac department: this device has a typeface similar to that of an ordinary typewriter (Fig. 3). On to this report the secretaries transcribe the results of any blood tests, photocopy the finished report (Fig. 4), and distribute it to the referring clinician, the patient's gen-

eral practitioner, the case notes, departmental files and, where appropriate, to our surgical colleagues.

INVESTIGATIONS OMR FORM

This document (Fig. 5) is used to record the results of more specialised investigations relevant to patients with cardiorespiratory disease. The various sections of the document include provision for recording the patient's identification including hospital number and

PHYSICAL EXAMINATION:
The patient was not overweight with good teeth
Arterial blood pressure was 160 / 80 (lying)
Pulse rate was in the range 51-90 /min in sinus rhythm
Venous pressure was 1 cm above the sternal angle, waveform showed a<v
Ventricular impulse graded at LV 1 /4; RV 0 /4; PA 0 /4
Auscultation :- a single non-ejection click
late mitral systolic murmur of intensity grade 1 /4
early diastolic (aortic) murmur of intensity grade
1 /4 and length 1 /4
Abdominal examination revealed an tender the right

This document is attached to the manuscript catheter record and is a summary of its contents. It allows the following to be recorded:

ST. THOMAS' HOSPITAL S.E.1 7EH
DEPARTMENT OF CARDIOLOGY

CS: 204(003)

Name : FREDERICK, - male caucasian Age 59
Address : ROAD, KENT (DOB 22.22)

GP: Dr , 1 Chislehurst Road, Orpington, Kent.

Referral: GP not from London area

Diagnosis: coronary artery disease chronic ischaemic heart disease,
coronary artery disease angina pectoris, anteroseptal
infarct, anterolateral infarct, left anterior hemiblock

Seen as a new patient on 23 SEP 81 by MWP

PAST HISTORY:
1980 polio affecting legs. 1980 appendicitis and
peritonitis. 1968 myocardial infarct. 1971, 1973, 1975 and 1977
paroxysmal tachycardia requiring admission to hospital. 1980
cholecystectomy. 1981 DV. Hypercholesterolaemia discovered
1966 - hypothyroidism diagnosed. Feelings of impending disaster.
Finds stress difficult.

FAMILY HISTORY:
Father died aged 62 of myocardial infarction. Brother
has had myocardial infarction.

TREATMENT:
L-Thyroxine 0.15 mg per day.
in the past has had Clofibrate, Betacodone 80 mgs per day

PRESENT SYMPTOMS:
Effort intolerance grade 2 (NYHA) limited by shortness of breath
Ex-smoker of tobacco
Symptoms included angina, palpitation, atypical pain
for 3 years

PHYSICAL EXAMINATION:
The patient was not overweight with good teeth
Arterial blood pressure was 160 / 80 (lying)
Pulse rate was in the range 51-90 /min in sinus rhythm
Venous pressure was 1 cm above the sternal angle, waveform showed a c v
Ventricular impulse graded at LV 1 / 4; RV 0 / 4; PA 0 / 4
Auscultation :- a single non-ejection click
late mitral systolic murmur of intensity grade 1 / 4
early diastolic (aortic) murmur of intensity grade
1 / 4 and length 1 / 4

Abdominal examination revealed an evoked tenderness in the right upper
quadrant
The urine contained protein

The following were normal:-
respiratory system, CNS, peripheral pulses, liver

Continued above right

CHEST X-RAY:
Cardiothoracic ratio 15 / 31

ECG:
Sinus rhythm with a P-R interval of 0.16 sec
The cardiac axis was at -40 deg.
max S wave on V1/2 30 mm, R wave on V5/6 10 mm
The findings were consistent with left anterior hemiblock, an old
myocardial infarct (anteroseptal & anterolateral)

ECNOCARDIOGRAM:
NV closure rate 60 mm/sec, NV excursion 15 mm, LA size 41 mm, aorta 34
mm, posterior wall 10 mm, septum 14 mm,
internal LV diameter - diastolic 60 mm, internal LV diameter - systolic
38 mm
Evidence of mitral valve/septal flutter consistent with aortic
regurgitation

The patient will be seen again here in 6 weeks

Further investigations summary as at 23 SEP 81

MYOCARDIAL PERFUSION SCAN	: Abnormal
EXERCISE ECG	: Abnormal
24hr ECG	: result to follow

MYOCARDIAL PERFUSION SCAN using Thallium 201
Suggested an inferior reversible defect
anteroseptal & anterolateral fixed defect
inferior equivocal area

EXERCISE ECG using leads CM4, CM5, CM6
Patient achieved 2 minutes into stage II of the Bruce protocol, test
terminated by chest pain, shortness of breath, fatigue
Subject attained 110 & predicted heart rate, 70 & predicted oxygen
consumption
Blood pressure at end of exercise test = 170 / 90 mm Hg

HbA1c 7.9	g/dl WBC 7.9/1	ESR 12 mm/hour	Hep. B antigen	NDG
Blood gp O+	PTT sec	VDRL/TPHA	NDG	
CHEN: Na 143	K 4.1	urea 7.4	Urate 0.46	
Ca++ 2.69	PO4 .9	Total Pr 76	Albumin 45 (gm/l)	
Alt Phos 8	Bil. N	ALT 12	Creat clear. ml/min	
Cholesterol 163	Trigly 3.6	Creatinine 107	Fasting glucose 4.4	
CPE	AST	HBD	20 mg/dl (435)	
T4	T3 binding	FTI	T3	TSH

Fig. 4 The clinical report. The bar at the right margin indicates the proportion derived from free text data.

- patient identification
- arterial and venous catheters used and their site of entry
- investigative procedures employed
- complications of catheterisation
- diagnoses, 70 of which may be marked but others may be coded and keyed in
- angiographic findings
- a summary of the haemodynamic indices.

The marking of this form is partly done by technical staff during the procedure and completed by clinical staff after the angiographic and other data have been analysed. The OMR forms are then fed in by secretaries who also key in any extra diagnoses or complications which could not be marked on the form. A brief report is produced by the computer but this is used only to check the data and is then discarded.

Analysis facilities

The most useful output derived from the patient examination and investigations OMR forms is the clinical report: these data and that from the catheter OMR form, however, may also be analysed to pro-

duce various tabulations which help the department perform more effectively. Several analyses are available of which the most important are an audit, a breakdown of costs, and an extract facility.

AUDIT

This examines all catheterisations within a stated interval and lists the catheters used, entry sites, and procedures employed against the incidence of complications. This information is used to prepare the annual catheter laboratory report and to review complication rates associated with each technique.

COSTS

The computer automatically accumulates the cost of each catheterisation by individually costing the various types of catheter used, the angiogram(s), and procedure(s). These costs may be listed by operator, time, and source of referral; the output is prepared overnight after the request has been entered on the terminal in the cardiac department.

EXTRACT

This is the most important analysis facility available on the system. It enables the rapid identification of all

Fig. 5 The investigations OMR form.

It is possible to manipulate several scans so as to satisfy more sophisticated requirements involving logically linked series of criteria. The process of extraction occurs during the conversation between researcher, using a keyboard, and the computer. The system can also subsequently produce a complete print out of all selected records.

Other analyses include listings of diagnosis frequency and a breakdown of workload by consultant and referral source. The record linkage capability of

the system may be used to perform longitudinal studies on any defined variable, for example effort intolerance, blood pressure.

Development

The system was developed with eight months of analyst and programmer effort over a seven year period since 1974. A further three weeks were spent by clinical staff defining their requirements and assessing the results. The computer programmes were written in FORTRAN IV using software originally developed for the microbiology system at St Thomas's.⁶ Considerable effort was invested in the design of this software to ensure that changes to the system, and in particular to the number and design of both OMR forms and reports, could be made with the minimum of effort and delay.⁷ Many changes can be made without any reprogramming. The computer holds 4500 catheter records going back to 1973 and 5000 examination records since 1976, 1500 of which relate to outpatients. The investigations OMR form has only recently been added to the system and as yet only 250 documents have been fed in. A total of 50 OMR forms are entered each week.

Results

The system is operated entirely by the staff of the cardiac department who readily absorbed its routine operation into their daily work. The marking of OMR forms was unexpectedly easy and rapid. The patient examination form was the most time-consuming and takes approximately 10 minutes to complete, but so did the previous task of dictation which it replaced. To mark each investigation and catheter OMR form is a trivial task and takes at most a few minutes. To enter the 50 OMR forms into the computer takes 40 minutes each week, of which 30 are spent commuting to and from the microbiology laboratory where the OMR device is located. To annotate the records takes a weekly total of two-and-a-half hours of secretarial time, most of which is spent typing in free text. Each report takes two minutes to print, but since it is done by the unattended operation of the computer terminal, no further secretarial time is involved. The addition of laboratory results, photocopying, and distribution are all tasks unchanged from the previous system. The time spent by technical and clinical staff in running the system thus shows no significant change from previous methods. Each week our secretarial staff take some three-and-a-half hours to process 50 documents. This compares very favourably with the equivalent time of 25 hours previously spent typing the dictated letters.

The savings effected by the various analyses and

listings produced by the computer are more difficult to quantify. The annual catheter laboratory report used to take a doctor 10 days to prepare, most of which was spent on the manual assembly of analysis sheets. The audit facility has reduced this to one day actually writing the report. The costing figures prove extremely useful in convincing the administration not only that the department cares about cost but also that cardiac investigations are not as expensive as it thought! The extract facility was, and with increasing frequency continues to be, used to identify groups of patients for teaching or research purposes. Examples of the ways in which the system helps our research activities include:

- a review of the electromagnetic flow probe⁸
- factors determining angina in aortic stenosis⁹
- the results of endomyocardial biopsy studies in mitral leaflet prolapse¹⁰
- visual complications of mitral leaflet prolapse.¹¹

To identify all patients in these categories would have meant checking by hand all the manuscript catheter records, a prohibitively time-consuming and boring task; using the computer it was done in minutes rather than months.

Our problems lie mainly in the shared use of the OMR device and the unreliability of the central computer. Commuting to and from the microbiology laboratory accounts for much of the time spent entering OMR forms and is particularly tiresome when errors require forms to be re-entered. The obvious solution for this (a second OMR) was impractical because of the high cost (£11 000) of the reading devices. Unreliability of both mark reader and central computer is a problem but seldom causes more than minor inconvenience. Our system was designed so as to tolerate unavailability of the computer for up to two days continuously and this limit has only been exceeded on two occasions in six years. There is a small but continuing requirement for retrospective manipulation of the files by our computer department. Inappropriate marking of the OMR forms by new clinical staff is a recurrent minor irritation but this soon responds to correction and encouragement from our secretaries.

Discussion

There is little doubt that computers can be of great value in the production of management and research statistics if, and only if, they can be used to record accurate and complete information economically. In many cases the computer may also help the routine operation of a clinical or paraclinical department. The production of analytical forms of output presents no major computer programming or organisational problems. The major difficulty in clinical work is record-

ing the patient data and this we believe can be overcome given a recording technique appropriate to the data involved, and a computer system of sufficient flexibility and reliability. The system we describe achieves during its routine operation a net saving of 22 hours of secretarial time per week and provides a management and research tool of great power and utility. Furthermore, it has been implemented with virtually no opposition from those who use it. We ascribe this firstly to the OMR techniques used, secondly to the flexibility of the computer programs, and thirdly to the careful avoidance of any duplication of work, however temporary, during the transition from manual to automated methods. The system was therefore seen from the outset to be easy to use, easy to modify, and to involve less and not more work for those concerned with its day to day operation.

Reliability and local control of development would be improved by the use of a mini- or microcomputer dedicated to our department, particularly if it formed part of a network linked to other applications. Such an arrangement would also provide much needed insurance against failure.

We have not been able wholly to computerise our clinical record. Much of the text which is currently typed in, and merely reproduced verbatim on our clinical reports, could well be supplied by interaction with other computer applications participating in a network. Thus treatment details could be supplied by a pharmacy application, the past history from a diagnostic system with record linkage capability, and the laboratory results included automatically rather than transcribed as at present. Despite this, a clinical report must be complete and we do not therefore foresee a time when free text can be completely eliminated from our system.

Design of suitable OMR forms would permit similar applications in other fields such as insurance medical examinations, industrial health, and the health records of the armed forces. For such purposes these forms would not only allow for the easy storage, retrieval, and analysis of large quantities of data but would also encourage the uniform recording of clinical information by different clinicians. Whether or not doctors in other specialities would find the method suitable would depend on the computer facilities to which they had access, the nature and extent of the information they wish to record, and the determination and enthusiasm that they, and the computer staff they employ, apply to the problem. While cardiology undoubtedly forms but a subset of general medicine, we believe that it is not such a super speciality that our results are not applicable elsewhere.

Williams, Brooksby, Morrice, Housego, Webb-Peploe

Unless medical computing can be seen to work in the routine clinical environment to the satisfaction of clinical and ancillary staff, and of a cost conscious and sceptical administration, then there is a danger that computer professionals will increasingly regard it as difficult and unrewarding and that clinicians will continue to view computer systems as expensive, time-consuming, and unproductive gimmicks.

References

- 1 Kennedy F, Cleary JJ, Roy AD, Kay AW. SWITCH—a system producing a full hospital case-history on computer. *Lancet* 1968; ii: 1230–3.
- 2 Brown JJ. Computer-based records in the clinic (b). *Proc Roy Soc Lond [Biol]* 1973; 184: 399–402.
- 3 Robertson JWK. Medical information systems incorporating automatic coding of text. In: Shires DB, Wolf H, eds. *Medinfo 77*. 2nd ed. New York: North-Holland, 1977: 271–5.
- 4 Bevan N, Pobgee P, Somerville S. MICKIE—a microcomputer for medical interviewing. *International Journal Man-Machine Studies* 1981; 14: 39–47.
- 5 Opit LJ, Woodroffe FJ. Computer-held clinical record system—I, Description of system. *Br Med J* 1970; iv: 76–9.
- 6 Williams KN, Davidson JMF, Lynn R, Rice E, Phillips I. A computer system for clinical microbiology. *J Clin Pathol* 1978; 31: 1193–201.
- 7 Davidson JMF, Williams KN, Robertson VS. Table-driven and Optical Mark Reader systems for clinical and laboratory applications. In: Barber B, Grémy F, Überla K, Wagner G, eds. *Medical informatics, Berlin 79. (International Conference on Medical Computing Proceedings.) (Lecture notes in medical informatics, vol 5.)* Berlin: Springer, 1979: 414–26.
- 8 Kolettis M, Jenkins BS, Webb-Peploe MM. Assessment of left ventricular function by indices derived from aortic flow velocity. *Br Heart J* 1976; 38: 18–31.
- 9 Swanton RH, Brooksby IAB, Jenkins BS, et al. Determinants of angina in aortic stenosis and the importance of coronary arteriography. *Br Heart J* 1977; 39: 1347–52.
- 10 Malcolm AD, Canković-Darracott S, Chayen J, Jenkins BS, Webb-Peploe MM. Biopsy evidence of left ventricular myocardial abnormality in patients with mitral-leaflet prolapse and chest pain. *Lancet* 1979; i: 1052–5.
- 11 Wilson LA, Keeling PWN, Malcolm AD, Ross-Russell RW, Webb-Peploe MM. Visual complications of mitral leaflet prolapse. *Br Med J* 1977; ii: 86–8.

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