British Heart Journal, 1974, **36**, 1213-1224.

Computer processing of cardiac catheterization data

J. P. Blackburn, E. A. Christopher,[1] L. Cillie, D. C. Deuchar, P. R. Fleming, G. A. H. Miller, and D. G. Morgan[2]

From the Medical Computer Centre, the Department of Clinical Measurement and the Medical Unit, Westminster Hospital; the Cardiac Department, Brompton Hospital; and the Cardiac Department, Guy's Hospital, London

A set of forms suitable for digital computer processing has been designed for manual data entry by the investigator after cardiac catheterization. The computer produces the catheterization report and a data bank is being built up for information retrieval and statistical analysis. A number of hospitals have been using the system since 1970 and the records of over 1000 cases are collected annually.

The process of extracting information about a series of cases investigated by cardiac catheterization or of analysing the work of one cardiac centre is very time consuming when this has to be done by hand, whereas data stored in a computer are easily available and may be analysed by complex statistical methods. Such analyses may then point to the need for improvements in methods of investigation or lead to increased diagnostic accuracy (Wallace and Rosati, 1973). Partial automation of a cardiac catheterization data retrieval system and its trial in a number of hospitals was, therefore, considered worth while. A method for on-line analysis of signals obtained during cardiac catheterization has been described (Henry *et al.*, 1968), but it was decided that a fully automated system was not justified at this stage.

A simple set of forms was produced so that data could be entered directly by the cardiologist after the investigation and the forms sent to the computer centre for processing. Hospitals wishing to use the system did not have to buy expensive equipment or modify their cardiac catheterization procedure appreciably.

It was considered important that the work load on the cardiologist should not be increased and that the computer must produce an acceptable cardiac catheterization report. In addition, a copy of the data entry form had to be easily interpretable by the clinician, so that it could be used until the computer report was available.

Received 8 April 1974.

[1]Present address: Computer Instrumentation Ltd., School Lane, Chandlers Ford, Hants.

[2]Present address: Department of Health & Social Security, Ray House, 6 St. Andrew's Street, London EC 4A.

Method

Careful initial planning of the service with agreement between the hospitals concerned on certain points of technique, the scope of the computer processing, and the format of the catheter report have been essential features contributing largely to the success of this project. All participants agreed to standardize their manometry using midchest as the zero reference and to time events by using elapsed time from the start of the operation. The layout of the data forms, the extent of the information to be included, and the method of presenting the results were all discussed in detail before the forms were designed and printed.

The form consists of four double sheets of pressure sensitive NCR paper illustrated in Fig. 1 a and b, 2, 3, and 4. The cardiologist fills in and retains the top copies as temporary reports and the information is duplicated automatically on the lower copies which are specially designed so that the data can be easily coded on 80 column IBM cards. These copies are sent to the computer centre for coding, and processing is carried out on an IBM 1800 computer at the Medical Computer Centre, Westminster Hospital. The data are stored on magnetic tape for subsequent retrieval and analysis.

All information is entered in numerical form in fixed format except for the patient's name, number, and diagnosis. In addition, a fifth sheet (not illustrated) is available for entering information about the results of angiographic studies or special investigations (such as intracardiac phonocardiography or electrocardiography). This information is not coded, but the computer can identify those patients on whom special studies have been performed using the 'other procedures' codes on sheet 2, so that the cardiologist can refer to the original records easily when required.

CARDIAC CATHETERISATION REPORT SHEET 1

HOSPITAL

REGD. No. DATE DAY MONTH YEAR

HOSPITAL No. CATHETER No.

STUDY 1 FIRST 2 REPEAT CINE No. ELEMA No.

NAME

SEX 1 MALE 2 FEMALE AGE YEARS MONTHS DAYS

HEIGHT CMS. WEIGHT KG. SURFACE AREA SQ.M.

OPERATOR 1 2 ANAESTHETIST

CLINICAL DIAGNOSIS

CODE AETIOLOGY

CATHETER DIAGNOSIS

CODE AETIOLOGY

PREMEDICATION

DRUG CODE TOTAL DOSE MGM. MGM. MGM. MGM.

NONE: LEAVE BLANK
01 ATROPINE
02 RECTAL THIOPENTONE (PENTOTHAL)
03 HYOSCINE (SCOPOLAMINE)
04 PROMETHAZINE (PHENERGAN)
05 TRIMEPRAZINE (VALLERGAN)
06 DIAZEPAM (VALLIUM)
07 PROMAZINE (SPARINE)
08 PETHIDINE
09 AMYLOBARBITONE (AMYTAL)
10 PAPAVERETUM (OMNOPON)
11 MORPHINE
12 CHLORPROMAZINE (LARGACTIL)
13 PHENOBARBITONE
14 CHLORAL
99 OTHER

ANAESTHESIA

INTRAVENOUS

DRUG CODE TOTAL DOSE MGM. MGM. MGM. MGM. MGM. MGM.

DO NOT CODE DRUGS USED TO REVERSE NEUROMUSCULAR BLOCK

NONE: LEAVE BLANK
1 ATROPINE
2 THIOPENTONE (PENTOTHAL)
3 SUXAMETHONIUM (SCOLINE)
4 CURARE
5 GALLAMINE (FLAXEDIL)
6 DIAZEPAM (VALIUM)
7 PANCURONIUM (PAVULON)
8 PETHIDINE
9 OTHER

INHALATIONAL

O_2 % 999 AUGMENTED OXYGEN

N_2O %

CODE %

%

NONE: LEAVE BLANK
1 HALOTHANE
2 TRILENE
3 PENTHRANE
4 CYCLOPROPANE
9 OTHER

INHALATIONAL INDUCTION AGENT

INTUBATION/I.P.P.R.
1 NEITHER
2 INTUBATION ONLY
3 INTUBATION & I.P.P.R.

FIG. 1, a and b *Upper and lower copies of the first sheet of the cardiac catheterization data entry form. The top copy is retained by the cardiologist and the lower copy sent to the computer centre for processing.*

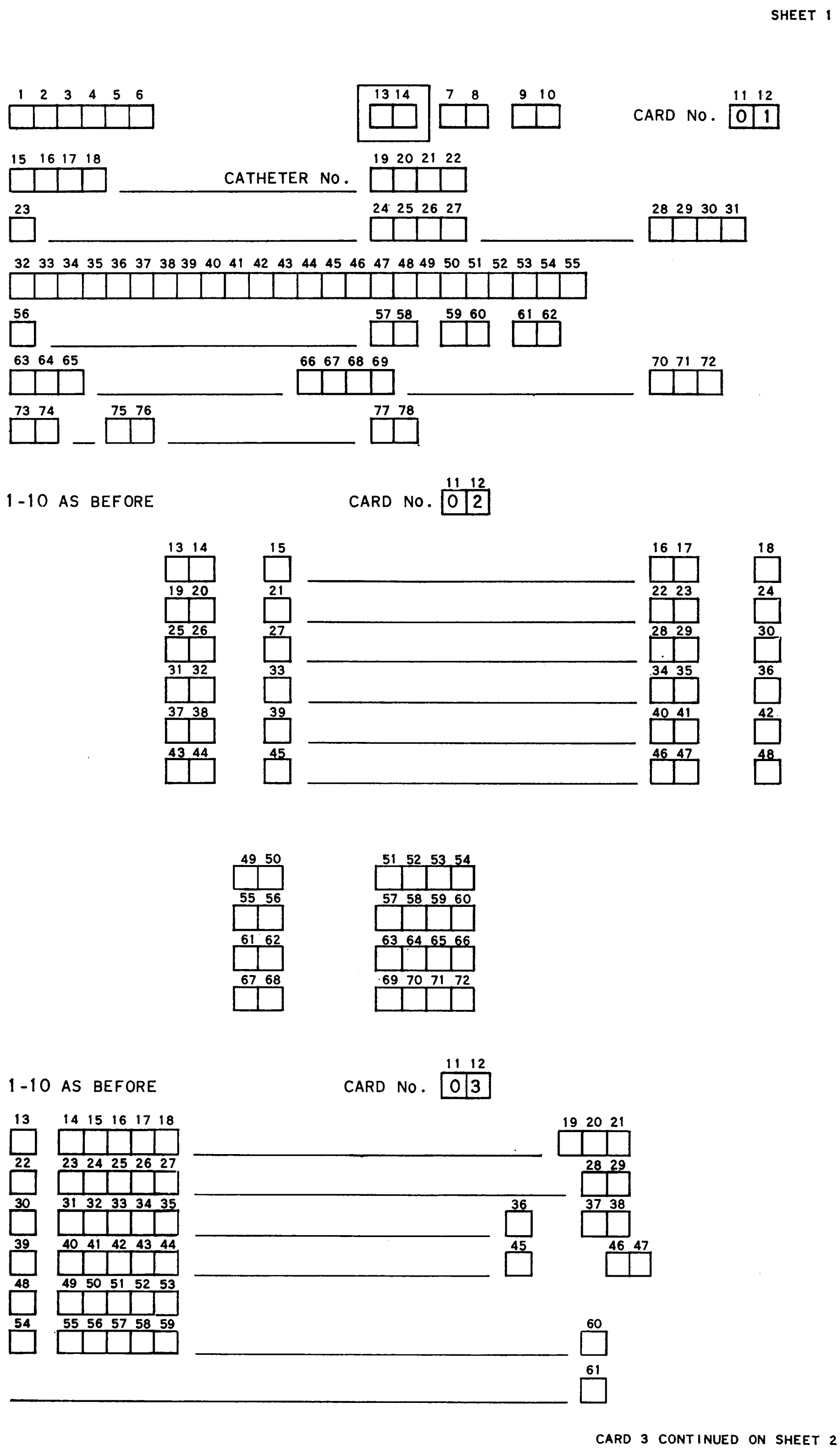

SHEET 1
1 2 3 4 5 6
13 14
7 8
9 10
CARD No. 0 1
11 12
15 16 17 18
CATHETER No.
19 20 21 22
23
24 25 26 27
28 29 30 31
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55
56
57 58
59 60
61 62
63 64 65
66 67 68 69
70 71 72
73 74
75 76
77 78
1-10 AS BEFORE
CARD No. 0 2
1-10 AS BEFORE
CARD No. 0 3
CARD 3 CONTINUED ON SHEET 2

FIG. 1b

SHEET 2

CATHETER No. [ ][ ][ ][ ]

ALL CATHETERS OUT [ ][ ][ ] MINS. ELAPSED TIME

OTHER PROCEDURES [ ] [ ] [ ]

SCREENING TIME [ ][ ] MINS.

COMPLICATIONS [ ] 1 NONE 2 MAJOR

OBJECT OF PROCEDURE. [ ] 1 ACHIEVED 2 PARTIALLY ACHIEVED 3 NOT ACHIEVED

RISK [ ] 1 GOOD 2 BAD

OTHER PROCEDURES

1 INTRACARDIAC PHONO.
2 INTRACARDIAC E.C.G.
3 INTRACARDIAC MANOMETRY
4 INDICATOR DILUTION CURVES
5 FLOW GUIDED CATHETERS
9 OTHER

PROCEDURE

ENTER CODE

.1 AREA ENTERED
2 SITE OF CINE
3 SITE OF BIPLANE
4 SITE OF BIPLANE AND CINE

* PROCEDURE	† METHOD	$ ENTRY SITE	S.V.C.01	I.V.C.02	R.A.03	C.S.04	R.V.05	P.A.06	P.A.W.07	P.V.08	L.A.09	L.V.10	AORTA 11	C.A.RT.12	C.A.LT.13	OTHER ** ENTER CODE

X-RAY PARTICULARS

ENTER AREA CODE	CONTRAST MEDIUM †† TYPE	CONTRAST MEDIUM †† DOSE C.C.	ENTER AREA CODE	CONTRAST MEDIUM †† TYPE	CONTRAST MEDIUM †† DOSE C.C.	ENTER AREA CODE	CONTRAST MEDIUM †† TYPE	CONTRAST MEDIUM †† DOSE C.C.

CODES

PROCEDURE *

1 RT. HEART
2 TRANS SEPTAL
3 L.V. PUNCTURE
4 RETROGRADE ARTERIAL
5 INDWELLING ARTERIAL NEEDLE
6 SUPRASTERNAL PUNCTURE
7 POSTERIOR THORACIC (L.A.)
8 ATRIAL SEPTOSTOMY
9 OTHER

METHOD †

1 PERCUTANEOUS
2 CUT-DOWN

ENTRY SITE $

1 ANTECUBITAL VEIN
2 SAPHENOUS VEIN
3 FEMORAL VEIN
4 AXILLARY VEIN
5 SUBCLAVIAN VEIN
6 BRACHIAL ART.
7 FEMORAL ART.
8 AXILLARY ART.
9 OTHER

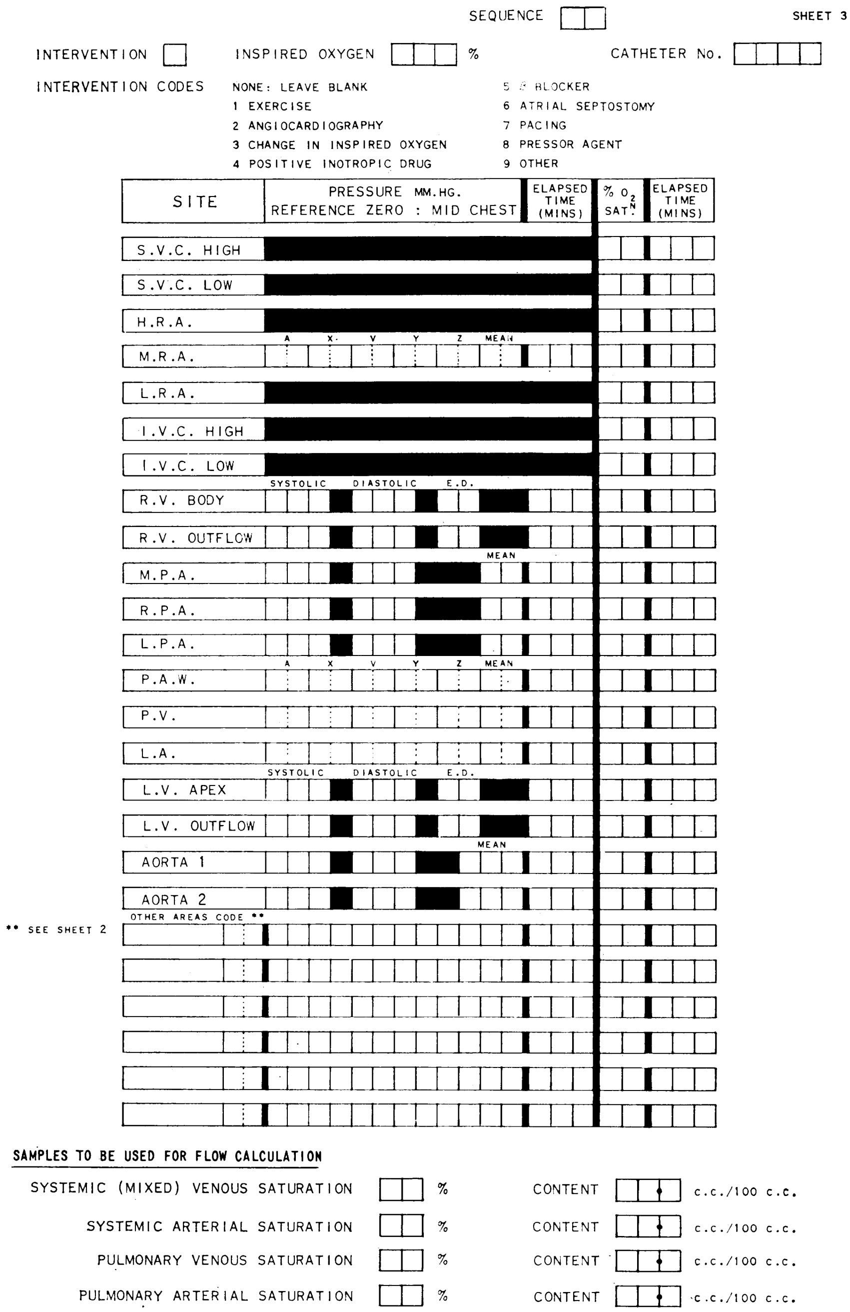
OTHER AREAS ENTERED **

14 LT. S.V.C.
15 INNOMINATE VEIN
16 COMMON ANOMALOUS P.V.
17 RT. ANOMALOUS P.V.
18 LT. ANOMALOUS P.V.
19 P.D.A.
20 COMMON (SINGLE) VENTRICLE
21 PERSISTENT TRUNCUS
22 WEDGE P.V.
23 RT. P.A.
24 LT. P.A.
25 SYSTEMIC ART. RT. ARM
26 SYSTEMIC ART. LT. ARM
27 SYSTEMIC ART. RT. LEG
28 SYSTEMIC ART. LT. LEG
29 AZYGOS VEIN

CONTRAST MEDIUM ††

1 HYPAQUE 45%
2 HYPAQUE 65%
3 HYPAQUE 85%
4 TRIOSIL 75%
5 UROGRAFIN 76
6 CONRAY 280
7 CONRAY 420
8 CARDIOCONRAY
9 OTHER

FIG. 2, 3, 4. *Top copies of the other sheets used for recording details of the procedure and results.*



SEQUENCE

SHEET 3

INTERVENTION

INSPIRED OXYGEN %

CATHETER No.

INTERVENTION CODES

NONE: LEAVE BLANK
1 EXERCISE
2 ANGIOCARDIOGRAPHY
3 CHANGE IN INSPIRED OXYGEN
4 POSITIVE INOTROPIC DRUG
5 β BLOCKER
6 ATRIAL SEPTOSTOMY
7 PACING
8 PRESSOR AGENT
9 OTHER

SITE	PRESSURE MM.HG. REFERENCE ZERO : MID CHEST	ELAPSED TIME (MINS)	% O_2 SAT^N	ELAPSED TIME (MINS)
S.V.C. HIGH				
S.V.C. LOW				
H.R.A.				
M.R.A.	A X V Y Z MEAN			
L.R.A.				
I.V.C. HIGH				
I.V.C. LOW				
R.V. BODY	SYSTOLIC DIASTOLIC E.D.			
R.V. OUTFLOW				
M.P.A.	MEAN			
R.P.A.				
L.P.A.				
P.A.W.	A X V Y Z MEAN			
P.V.				
L.A.				
L.V. APEX	SYSTOLIC DIASTOLIC E.D.			
L.V. OUTFLOW				
AORTA 1	MEAN			
AORTA 2				
OTHER AREAS CODE **				

** SEE SHEET 2

SAMPLES TO BE USED FOR FLOW CALCULATION

SYSTEMIC (MIXED) VENOUS SATURATION % CONTENT c.c./100 c.c.

SYSTEMIC ARTERIAL SATURATION % CONTENT c.c./100 c.c.

PULMONARY VENOUS SATURATION % CONTENT c.c./100 c.c.

PULMONARY ARTERIAL SATURATION % CONTENT c.c./100 c.c.

FIG. 3

SEQUENCE [|]

SHEET 4

INTERVENTION CODE [ ] SEE SHEET 3

CATHETER No. [| | |]

PEAK GRADIENTS

DESIGNATION [ ] [| |] MM.HG. DESIGNATION [ ] [| |] MM.HG. DESIGNATION [ ] [| |] MM.HG.

MEAN GRADIENTS

DESIGNATION [ ] [| |] MM.HG. DESIGNATION [ ] [| |] MM.HG. DESIGNATION [ ] [| |] MM.HG.

DESIGNATION CODES:
1 TRICUSPID VALVE
2 PULMONARY VALVE
3 PERIPHERAL PULM. ART.
4 MITRAL VALVE
5 L.V. (SUB AORTIC)
6 AORTIC VALVE
7 AORTA (SUPRA VALVE)
8 COARCTATION
9 OTHER

BLOOD GASES (ARTERIAL)

ELAPSED TIME [| |] MINS.
PO_2 [| |] MM.HG. PCO_2 [| |] MM.HG.
HCO_3^- [| |] M.EQ./L PH [| | |]

ELAPSED TIME [| |] MINS.
PO_2 [| |] MM.HG. PCO_2 [| |] MM.HG.
HCO_3^- [| |] M.EQ./L PH [| | |]

DATA FOR FLOW CALCULATIONS

FLOW CALCULATION METHOD [ ] 1 INDICATOR DILUTION 2 FICK PRINCIPLE

OXYGEN SATURATION METHOD [ ] 1 OXIMETRY 2 VAN SLYKE 9 OTHER

OXYGEN CONSUMPTION METHOD [ ] 1 ASSUMED BASAL 2 EXPIRED AIR ANALYSIS 3 SPIROMETRY 9 OTHER

OXYGEN CONSUMPTION [| |] C.C./MIN./SQ.M. ELAPSED TIME [| |] MINS. IF PERFORMED OUTSIDE CATHETERISATION CODE 999

HAEMOGLOBIN [| |] GM% OXYGEN CAPACITY [| |] C.C./100 C.C.

EXPIRED AIR ANALYSIS

TOTAL VOL. EXPIRED AIR [| |] L. DURATION OF COLLECTION [| |] MINS.

OXYGEN IN EXPIRED AIR [| | |] % CO_2 IN EXPIRED AIR [| |] %

ROOM TEMPERATURE [| |] °C BAROMETRIC PRESS. [| |] MM.HG.

CALCULATIONS

FLOWS

PULMONARY ($\dot{Q}P$) [| |] L./MIN./SQ.M.
SYSTEMIC ($\dot{Q}S$) [| |] L./MIN./SQ.M.
RATIO ($\dot{Q}P/\dot{Q}S$) [| |]
EFFECTIVE PULM. [| |] L./MIN./SQ.M.

RESISTANCES

TOTAL PULMONARY (R_P) [| |] UNITS x SQ.M.
PULMONARY ARTERIOLAR (R_{Pa}) [| |] UNITS x SQ.M.
SYSTEMIC (R_S) [| |] UNITS x SQ.M.
RATIO (R_P/R_S) [| |]

SHUNTS

LEFT TO RIGHT [| |] L./MIN./SQ.M. [|] %
RIGHT TO LEFT [| |] L./MIN./SQ.M. [|] %

FIG. 4

TABLE I *Aetiological and diagnostic codes*

Aetiology
1 No organic heart disease
2 Congenital
3 Rheumatic
4 Arteriosclerotic
5 Other acquired
6 Mixed or indeterminate

	Presence		*Severity of condition*		
	Diagnosis	*Query Diagnosis*	*Mild*	*Severe*	*Query severity*
No anatomical lesion	1	0B	0Q	A1	P1
Atrial septal defect, secundum	2	0C	0R	A2	P2
Atrial septal defect, sinus venosus defect	3	0D	0S	A3	P3
Endocardial cushion defect	4	0E	0T	A4	P4
Common atrium	5	0F	0U	A5	P5
Total anomalous pulmonary venous return	6	0G	0V	A6	P6
Hemianomalous pulmonary venous return	7	0H	0W	A7	P7
Left ventricle to right atrial fistula: Gerbode defect	8	0I	0X	A8	P8
Ventricular septal defect	9	0J	0Y	A9	P9
Ventricular septal defect with pulmonary stenosis	10	1A	1P	B0	Q0
Ventricular septal defect with pulmonary atresia	11	1B	1Q	B1	Q1
Common ventricle	12	1C	1R	B2	Q2
Tricuspid atresia	13	1D	1S	B3	Q3
Ebstein's anomaly of tricuspid valve	14	1E	1T	B4	Q4
Hypoplastic right ventricle and Uhl's syndrome	15	1F	1U	B5	Q5
Pulmonary stenosis, valvar	16	1G	1V	B6	Q6
Pulmonary stenosis, infundibular	17	1H	1W	B7	Q7
Pulmonary atresia, with intact ventricular septum	18	1I	1X	B8	Q8
Anomalous systemic venous return to left atrium	19	1J	1Y	B9	Q9
Anomalies of systemic venous return to right atrium	20	2A	2P	C0	R0
Persistent truncus arteriosus	21	2B	2Q	C1	R1
Aortico-pulmonary window	22	2C	2R	C2	R2
Persistent ductus arterious	23	2D	2S	C3	R3
Systemic-pulmonary arterial communication	24	2E	2T	C4	R4
Dextro-transposition	25	2F	2U	C5	R5
Laevo-transposition	26	2G	2V	C6	R6
Partial transposition	27	2H	2W	C7	R7
Dextrocardia	28	2I	2X	C8	R8
Isolated laevocardia	29	2J	2Y	C9	R9
Hypoplastic left heart syndrome	30	3A	3P	D0	S0
Anomalous origin of coronary arteries	31	3B	3Q	D1	S1
Infantile coronary artery disease	32	3C	3R	D2	S2
Coronary arteriovenous fistula	33	3D	3S	D3	S3
Ruptured sinus of Valsalva	34	3E	3T	D4	S4
Systemic arteriovenous fistula	35	3F	3U	D5	S5
Pulmonary arteriovenous fistula	36	3G	3V	D6	S6
Coarctation	37	3H	3W	D7	S7
Congenital interruption of aortic arch	38	3I	3X	D8	S8
Other aortic arch anomalies	39	3J	3Y	D9	S9
Cor triatriatum	40	4A	4P	E0	T0
Stenosis or thrombosis of pulmonary veins	41	4B	4Q	E1	T1
Peripheral pulmonary artery stenosis	42	4C	4R	E2	T2
Anomalies of pulmonary arteries	43	4D	4S	E3	T3
Primary pulmonary hypertension	44	4E	4T	E4	T4
Cor pulmonale	45	4F	4U	E5	T5
Thromboembolic pulmonary hypertension	46	4G	4V	E6	T6
Pulmonary embolism	47	4H	4W	E7	T7
Pulmonary hypertension	48	4I	4X	E8	T8
Primary myocardial disease	49	4J	4Y	E9	T9
Primary endocardial disease	50	5A	5P	F0	U0
Diverticulum of left ventricle	51	5B	5Q	F1	U1
Tricuspid stenosis	52	5C	5R	F2	U2
Tricuspid incompetence	53	5D	5S	F3	U3
Mitral stenosis	54	5E	5T	F4	U4

[*continued overleaf*]

TABLE 1—*continued*

	Presence		Severity of condition		
	Diagnosis	Query diagnosis	Mild	Severe	Query severity
Mitral incompetence	55	5F	5U	F5	U5
Mitral stenosis and incompetence	56	5G	5V	F6	U6
Pulmonary incompetence	57	5H	5W	F7	U7
Aortic stenosis-supravalvar	58	5I	5X	F8	U8
Aortic stenosis-valvar	59	5J	5Y	F9	U9
Aortic stenosis-subvalvar	60	6A	6P	G0	V0
Aortic incompetence	61	6B	6Q	G1	V1
Aortic stenosis (valvar) and incompetence	62	6C	6R	G2	V2
Aortic aneurysm	63	6D	6S	G3	V3
Dissection of aorta	64	6E	6T	G4	V4
Hypertrophic obstructive cardiomyopathy	65	6F	6U	G5	V5
Other cardiomyopathies	66	6G	6V	G6	V6
Coronary artery disease	67	6H	6W	G7	V7
Disease of right coronary artery	68	6I	6X	G8	V8
Disease of anterior descending coronary artery	69	6J	6Y	G9	V9
Disease of circumflex coronary artery	70	7A	7P	H0	W0
Myocardial infarction	71	7B	7Q	H1	W1
Ventricular aneurysm	72	7C	7R	H2	W2
Pericardial disease	73	7D	7S	H3	W3
Cardiac myxoma	74	7E	7T	H4	W4
Cardiac tumour	75	7F	7U	H5	W5
Heart block	76	7G	7V	H6	W6
Atrial fibrillation	77	7H	7W	H7	W7
Other arrhythmias	78	7I	7X	H8	W8
Systemic hypertension	79	7J	7Y	H9	W9
Postoperative study	80	8A	8P	I0	X0
Other	81	8B	8Q	I1	X1
Visceral situs-solitus	82	8C	8R	I2	X2
Visceral situs-inversus	83	8D	8S	I3	X3
Visceral situs-indeterminate	84	8E	8T	I4	X4

The first part of the form provides for the entry of hospital, patient, and physician identification data. Clinical diagnosis and the catheter diagnosis can also be entered. These diagnostic entries have to be coded for the computer; these codes are the only ones not printed on the form, but space is available for the diagnosis to be written directly for ease of interpretation. The diagnostic codes (Table 1) were specially developed so that the type, severity, and aetiology of most forms of congenital and acquired heart disease can be easily recorded. Details of sedation or of any anaesthetic technique can also be entered.

The section on 'procedure' (sheet 2) gives details of the mode of insertion of the catheter, vessels and cardiac chambers entered, the sites at which cine or serial film angiographic records were made, and the type and dose of contrast material used for these investigations. Thus simple right and left heart catheterization, with cine angiograms in the left ventricle and aorta, would be coded as shown in Fig. 5. Complications during cardiac catheterization are also coded very simply at the moment. If a significant complication rate is found, then a more comprehensive system, such as that described by Braunwald and Swan (1968), may be adopted in the future.

Results are entered on sheet 3. These are the values of blood pressure and oxygen saturation for that particular patient considered representative by the investigator. Elapsed time is also recorded so that the cardiologist can follow the time course of the investigation and interpret changes in oxygen saturation or pressure appropriately. The oxygen saturations or contents of blood samples suitable for calculating systemic and pulmonary blood flows are entered by the investigator at the bottom of sheet 3. Again he can use his own judgement in choosing values depending on the information available and the nature of the anatomical defect.

Sheet 4 is used for entering data about valve gradients, shunt flows and resistances, and the results of any determinations of cardiac output, which may be made by a variety of methods. The acid-base state of the patient can also be recorded if necessary. Results are entered by the investigator on this sheet, as they may be needed before the computer print-out is available. Mathematically the calculations are relatively trivial, but may be duplicated by the computer as part of the error checking system. Additional copies of sheets 3 and 4 may be used as often as required in any individual study to allow information to be entered following any of the interventions listed at the top of sheet 3. For instance, the effects of exercise, β-blockade, or oxygen inhalation

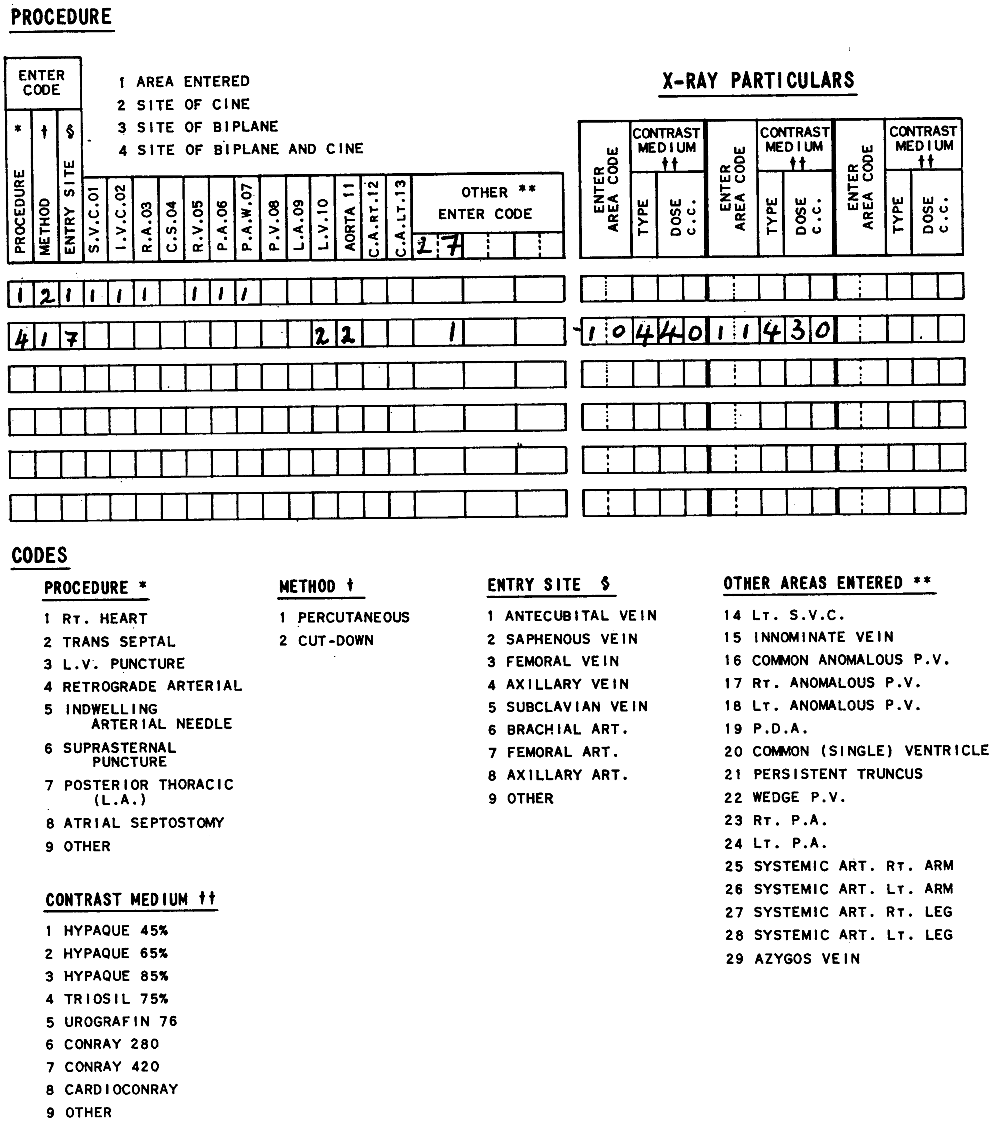


FIG. 5 *Part of sheet 2, showing coding for simple right and left heart catheterization, with cineangiograms in left ventricle and aorta.*

may be separately investigated and the results entered on the appropriate data sheets. A readily interpretable print-out suitable for inclusion in the patient's notes is obtained in standard format as shown in Fig. 6. Automatic error checking is not provided in the computer programme at the present time, but information in the data store on magnetic tape can be corrected if and when errors are detected on the print-out.

Results

The system has now been in operation since January 1970. A number of London hospitals have been associated with the scheme, namely the Brompton Hospital, Guy's Hospital, the London Chest Hospital, and Westminster Hospital. The Radcliffe Infirmary, Oxford, joined the group in 1973. The records of over 1000 cases are now collected annually. Initially forms were processed on a weekly basis to provide catheter reports, but now a twice weekly service has been introduced. The data forms and computer print-out have proved acceptable at most of the hospitals associated with the scheme and have largely replaced other methods of recording results and producing reports. At Guy's Hospital however the pre-existing reporting methods

The Brompton Hospital — Cardiac Catheterization Report No. 7307

Name = ***** Sex = Male Age = 3 Years
Date = 15 Oct 1973 Regd No. = ** Repeat study
Height = 93 cm Weight = 12·9 kg Surface area = 0·57 m^2
Cine no. = Elema no. = 2815

Clinical diagnosis

Congenital
  Pulmonary stenosis, valvar
  Query VSD

Catheter diagnosis

Congenital
  Laevo-transposition
  VSD
  Pulmonary stenosis, infundibular
  Visceral situs-solitus

Procedure

Operator = ***** Anaesthetist = ****

Premedication:	Papaveretum	= 4·0 mg
	Hyoscine	= 0·2 mg
	Diazepam	= 5·0 mg
Anaesthesia:	Thiopentone	= 62·5 mg
	Pancuronium	= 2·0 mg
	Oxygen	= 25 %
	Nitrous oxide	= 75 %
	Intubation/IPPR	

1. Rt. heart catheter Cut-down
   Axillary vein
   Sites reached = SVC
   IVC
   RA
   RV
   PA
   LV
   Aorta
   Biplane angiocardiogram in RV
   – Triosil 75% 20 ml

Other procedures = flow-guided catheters
Risk = good Complications = none
Object of procedure was achieved
Total duration = 50 minutes Screening time = 11 minutes

Site	Pressure (mmHg Reference Mid-chest)		Mean	Time elapsed (Min)	O_2 Satn (%)	Time Elapsed (Min)
SVC low					50	40
MRA	A = 11, X = 6,	Z = 8	8	24	50	39
IVC high					60	43
IVC low					64	42
RV body	102/ 8	ED = 11		28	60	28
RV outflow	24/10				78	38
MPA	24/15			38	74	37
LV outflow	102/ 8	ED = 18		26	97	26
Aorta I	102/70			25	97	25

FIG. 6 *Computer print-out of cardiac catheterization report (retyped). [continued opposite.]*

were retained and the computer system operated in parallel. The increased work load proved unacceptable to the investigators concerned, and Guy's Hospital left the group after the system had been in operation for about 18 months.

During the period 1970 to 1973, records of 5200 cases have been coded. Details of the aetiology of the lesions found at cardiac catheterization are shown in Table 2. Postoperative studies have been included separately as these are invariably repeat investigations. There has been a progressive increase in the number of cases of arteriosclerotic (coronary) heart disease investigated. Cases where the aetiology was unrecorded rose dramatically in 1973. This is probably because the number of cardiologists using the system has increased and many of them were not associated with the original design of the data entry form.

TABLE 2 *Numbers of patients in various aetiological groups since beginning of study: some had more than one aetiological diagnosis*

	1970	*1971*	*1972*	*1973*	*Total*
No organic heart disease	41	59	60	118	278
Congenital	526	545	566	699	2336
Rheumatic	225	192	224	247	888
Arteriosclerotic	50	118	184	370	722
Other acquired	173	186	180	204	743
Mixed or indeterminate	78	109	129	95	411
Postoperative study	80	73	112	99	364
Unrecorded	32	26	31	122	211
Total number of cardiac catheterizations	1045	1143	1266	1746	5200

Data for flow calculations

	Saturation (%)	Content (ml/100 ml)
Systemic (mixed) venous	58	8·2
Systemic arterial	97	14·0
Pulmonary venous	97	14·0
Pulmonary arterial	74	10·4

Flow measured by Fick principle
Oxygen saturation measured by oximetry
Oxygen consumption = 208 ml/min per m^2 (assumed basal)
Haemoglobin = 10·2 g/100 ml
Oxygen capacity = 14·1 ml/100 ml

Calculations

Pulmonary flow (QP)	= 5·8 l./min per m^2
Systemic flow (QS)	= 3·5 l./min per m^2
Pulmonary/systemic flow ratio (QP/QS)	= 1·7
Total pulmonary resistance (RP)	= 3·1 units × m^2
Left-to-right shunt	= 2·3 l./min per m^2

Peak gradient
pulmonary valve 78 mmHg

Discussion

In addition to providing a routine cardiac catheterization reporting system, the data bank can be used as a sophisticated card index and each hospital receives quarterly summaries of all cardiac catheterizations and an annual report. Lists of patients with a particular diagnosis or those catheterized in given age groups can be readily retrieved. Multiple correlations can also be performed, so that, for example, the effects of anaesthesia or the relation between age, procedure, and complication rate, can be established. A paper comparing the formulae used to estimate the oxygen saturation of mixed venous blood from vena caval samples (Miller, Brown, and Miller, 1974) illustrates one way in which the system has been used.

It is proposed to extend the system so that the catheter findings can be correlated with the surgical procedure, postoperative course, and long-term results of surgery.

References

Braunwald, E., and Swan, H. J. C. (1968). Co-operative study on cardiac catheterization. *Circulation*, **37**, Suppl. 3.

Henry, W. L., Crouse, L., Stenson, R., and Harrison, D. C. (1968). Computer analysis of cardiac catheterization data. *American Journal of Cardiology*, **22**, 696.

Miller, H. C., Brown, D. J., and Miller, G. A. H. (1974). Comparison of formulae used to estimate oxygen saturation of mixed venous blood from caval samples. *British Heart Journal*, **36**, 446.

Wallace, A. G., and Rosati, R. A. (1973). Computers can change cardiology. *Circulation*, **47**, 439.

Requests for reprints to Dr. J. P. Blackburn, Department of Clinical Measurement, Westminster Hospital, London S. W. 1.