The Glasgow Blood Pressure Clinic

By members of the Clinic*

Analysis of data from a large group of patients can sometimes produce information unobtainable from a smaller series (British Medical Bulletin, 1971). This is well illustrated in studies of hypertension (Evans and Rose, 1971; Pickering, 1968). The present report deals with the establishment in Glasgow of an organisation capable of investigating a large number of patients with raised blood pressure. Information from over 900 cases has been collected from hypertension clinics in four hospitals and stored in a computer data file. Three simple extract programs have been run to test the system.

Organisation of the Clinic

Geography and Resources
Glasgow has several natural advantages for a project of this type: over one million inhabitants are served by five teaching hospitals within five miles of each other. The necessary computer facilities and expertise in medical computing are already well developed in the city (Kennedy et al., 1968; Kennedy, 1970; Card, 1970; Aitchison, 1970; Aitchison et al., 1971; Taylor, 1970) and there are particular interests in vascular disease (Richards, 1970) and in the epidemiology (Hawthorne et al., 1969), radiology (Davidson, 1970), pathology (Macadam, 1969; Symington, 1969), surgery (Luke et al., 1968; Ferriss et al., 1970) and medical treatment (Fife et al., 1960; Kellett and Hamilton, 1970; Macdougall et al., 1970; Lawrie et al., 1964) of hypertension as well as in renal hypertension (Luke et al., 1968), malignant-phase hypertension (Gavras et al., 1971) and Conn’s syndrome (Ferriss et al., 1970).

Preliminary Negotiations
The project was considered first in 1967, and a working party, representing the teaching hospitals, decided to establish a central data-processing unit linked with hypertension clinics in four teaching hospitals. In May 1968 a part-time research assistant was appointed. Other staff—a secretary, data-processing personnel and a second part-time research assistant—were appointed as the project progressed. Policy decisions were taken by an executive committee and a small sub-committee concerned itself with medical records and computing.

* See page 96.
Outline of Clinic and Records System
The detailed operation of the project is considered in subsequent sections. The main events, as they affect an individual patient, are illustrated in Fig. 1. When the patient is first seen in the hospital clinic, information on history and physical examination is recorded on an initial acceptance proforma. This is edited and returned to the central data-processing unit where the information is punched on paper tape which is subsequently fed into a KDF9 digital computer (ICL) and stored on magnetic tape. A print-out of selected findings is returned to the patient's case notes in 1 to 7 days. When the patient is next seen, the computer print-out and the results of investigations are available. These, together with further measurements of blood pressure, new clinical features and details of therapy and adverse effects, are entered on a follow-up document which is processed in the same way.

Outpatient Clinics
At present, 7 clinics are held each week in 4 hospitals. Two clinics seeing hypertensive patients were already in existence at the Royal Infirmary before 1967 and it was a relatively simple matter to link these with the data-processing unit. New blood pressure clinics were opened at the Southern General Hospital, Stobhill General Hospital, and the Western Infirmary. All clinics are held in outpatient departments and use existing facilities for nursing and investigation. The medical staff are drawn from the departments whose consultants are involved in the project. Fifteen consultants and 13 registrars are currently working in rotation in the clinics. At least one of the two research assistants attends each session.

Between January 1969, when the first of the clinics opened, and 29
November 1971, 944 new patients were seen and there have been approximately 4,500 follow-up visits. Numbers attending the clinics are gradually increasing and current weekly rates (based on figures for the previous three months) are now 9·2 for new patients and 50 for follow-up visits. A recent (1 November 1971) computer extract indicated that of 900 patients seen, 283 had been referred from general practitioners, 510 from other hospital clinics, 38 from a cardio-respiratory screening survey (Hawthorne and Gillis, 1971), 3 from the Family Planning Association and 66 from other sources.

**Medical Records**
The SWITCH system developed by Kennedy and his colleagues (1968) was used as the basis of the medical record. An initial acceptance document is completed at the patient’s first visit and information is obtained on fifty features in the history and examination in such a way that it can be coded and transcribed to punched-paper tape with minimal editing and error. Some symptoms and signs are arbitrarily graded, others are recorded as absent or present. Provision is made for free comment on unusual aspects of the history or examination. It is possible to modify certain items, and a dictionary facility allows the clinician to use synonyms (Kennedy et al., 1968; Kennedy, 1970).

A similar but shorter document is used at follow-up visits to record new clinical features, current treatment and adverse effects. The results of investigations are entered on a separate document. Most information is recorded in a form suitable for coding and, again, facilities are provided for free comment.

**Data-processing and Computing**
The data-processing unit is accommodated at the Western Infirmary in the Department of Medical Computing where it shares equipment and personnel with the peptic ulcer project (Kennedy et al., 1968).

Acceptance and follow-up documents reach the unit on the day of completion. They are edited and coded by the research assistants, and punched-paper tape is prepared and verified using Friden Flexowriters. At one of two weekly sessions the tape is fed into a KDF9 computer owned by the University of Glasgow. A copy of the print-out is filed in the patients’ clinical folder, and data are stored on magnetic tape.

**Costs**
During its first seven years of operation the project is expected to cost approximately £41,000. A relatively large proportion of this represents capital expenditure, the most costly single items being the two Friden Flexowriters at £2,060 each. We have been fortunate in having free access to the KDF9
computer. Hiring time on an equivalent computer would have cost between £1,000 and £2,000 p.a.

Assuming operation at our present level for a further five years and allowing a 7-year life for capital equipment, the cost of documenting a patient in the Glasgow Blood Pressure Clinic, including follow-up visits, would be between £10 and £15. To this should be added the larger basic cost of seeing, investigating and treating a patient in a general medical clinic.

**EXTRACTION AND ANALYSIS OF DATA**

Between 50 and 250 items on each of 900 patients are recorded on magnetic tape. The information described earlier on the sources of patients was obtained by a simple extract program. Two further examples have been chosen to illustrate the potential of the system.

**Terminal Digit Preference in the Measurement of Blood Pressure**

Blood pressure is measured with the conventional sphygmomanometer and, also, in certain circumstances (particularly therapeutic trials), with the sphygmomanometer devised by Rose and his colleagues (1964). Measurements made with the two instruments agreed reasonably well (Fig. 2). However, values obtained with the conventional sphygmomanometer showed evidence of terminal digit preference (Rose et al., 1964), a disproportionately large number of observations ending in 0 or 5.

To test this further, a program was prepared and all 2,158 pairs of measurements of systolic and diastolic blood pressure made with the two instruments at the same clinic session were extracted from magnetic tape and printed by the computer as a frequency-distribution according to the value of the terminal digit. As can be seen in Fig. 3 there was a marked preponderance of readings ending in 5 when the conventional sphygmomanometer was used, with an even larger number ending in zero. No such tendency was apparent with the special sphygmomanometer.

**Computer Search for Conn’s Syndrome**

(a) **Criteria used.** Conn’s syndrome, a potentially curable form of hypertension, is usually associated with hypokalaemia and a plasma sodium concentration greater than 136 mEq/litre (Brown et al., 1968). Hypokalaemia in a hypertensive patient may also be due to treatment with diuretics or secondary hyperaldosteronism, usually associated with renal disease. In the latter instance, plasma sodium concentration is often less than 136 mEq/litre. With these observations in mind, an extract program was designed to print out electrolyte data in patients with hypokalaemia and to identify those known to
have been taking diuretics within one month of the low potassium value (Table 1). A search was also made for patients with Conn’s syndrome. As a test of the reliability of the extract, the hospital notes and computer documents were checked in all patients identified by the computer as having hypokalaemia and/or Conn’s syndrome.

(b) Identification of known cases. The records of 652 patients were on magnetic tape when the extract program was run in August 1971. Of 210 patients
identified as having either Conn’s syndrome and/or hypokalaemia (Table 1), 90 were taking diuretics.

Investigations for Conn’s syndrome had been completed in 20 patients. Of the 7 proven cases of Conn’s syndrome 4 did not have hypokalaemia (Table 1);
in 3 this was attributable to treatment with spironolactone (Brown et al., 1971). In 4 of 12 cases currently under investigation (Table 1) hypokalaemia was associated with low plasma renin concentration and normal or sub-normal plasma aldosterone. Excess corticosterone or desoxycorticosterone is being investigated as a possible cause of hypertension in these patients (Fraser et al., 1968; Brown et al., 1972).

(c) Identification of cases needing further investigation. Hypokalaemia had not been adequately investigated in 90 patients (Table 1). In 14 of these, preliminary investigations had been arranged, but in no case had investigation been taken to the point where the diagnosis could be excluded. No investigations had been undertaken in the remaining 76 patients. The hypokalaemia in this group was mostly mild or borderline in degree (Table 1); in 23 cases the lowest recorded potassium was 3.7 mEq/litre and while this falls within the limits of the normal range for the two laboratories estimating potassium in plasma rather than serum, cases of Conn’s syndrome have been found with plasma and serum values of 3.7 mEq/litre or more (Conn et al., 1966; Brown et al., 1968). In 32 patients the lowest potassium value was 3.5 or 3.6; in 18 it lay between 3.1 and 3.4, and in only three was it less than 3.1 mEq/litre.

Whether the eventual yield of proven cases of Conn’s syndrome in this group is high or low (and this is the subject of another study), the practical
point to emerge is that had the computer search not been made, investigation of 90 patients with suspected Conn’s syndrome would not now be taking place. Until the time of the search there was no agreed policy among clinicians on the level of plasma potassium justifying further investigation for Conn’s syndrome. While this certainly contributed to the large yield of suspects it is not the whole explanation since several cases were found in the clinic most familiar with the disease.

There has been much debate on the prevalence of Conn’s syndrome among hypertensive patients (Conn, 1965; Conn et al., 1966; Ledingham et al., 1967; Kaplan, 1969). That there should be disagreement is not surprising, since most data are derived from selected series. For the same reason, and also because investigations are incomplete, the present analysis throws no light on the controversy.

(d) Preparation and reliability of the extract program. It took 5 man-weeks to prepare and test the extract program, and although 6 hours of computer time were needed for the initial extract, a simplified program now runs in 13 minutes. This could (and has) been re-run at intervals as a means of screening the clinic for cases worthy of further investigation. The alternative, using traditional techniques, would be to locate and search by hand through more than 900 sets of hospital notes.

The largest source of error was the failure of clinicians to record that 33 of the 90 patients were taking diuretics. It is unlikely a similar mistake contributed to the many patients now suspected of having Conn’s syndrome since only those known not to be taking diuretics remain as suspects.

There were three other data-recording errors and four errors of data processing. A fault in the computer program leading to misclassification of patients was identified and corrected during a preliminary test.

**Discussion**

One objective of the Glasgow Blood Pressure Clinic was to store accessible data from a large number of hypertensive patients and to use this information for management and research. Although this paper is concerned with the establishment of the clinic and not with the analysis of data, three extracts were made to test the potential of the system.

Although the proforma used is probably an improvement on traditional methods of collecting and analysing clinical data, bias is not necessarily eliminated when specific questions are asked by an interviewer using a questionnaire (Cochrane et al., 1951; Elwood and Wood, 1966; Holland et al., 1966). Nor is the history given by a hypertensive patient particularly reliable (Stewart, 1953; Cochrane, 1969; Lever, 1970). It is likely therefore that the
information obtained in the Clinic is biased to some extent, and an investigation of the matter is in progress.

The variability of blood pressure is well known. Variation may result from genuine changes of pressure or from errors or bias due to inconsistency of the observer, differences between observers, and imprecision of the method used for measuring blood pressure (Armitage and Rose, 1966; Bevan et al., 1969; Gavras et al., 1971). The tendency (sometimes the deliberate policy) of medical staff to record blood pressure in round numbers is well known (Rose et al., 1964; Bevan et al., 1969) and evidence produced by ourselves (Fig. 3) and by Rose et al. (1964) suggests that the ‘special sphygmomanometer for epidemiologists’ greatly reduces this source of error.

Medical records and the computer. Much has been written on the value of the computer in the recording of medical data. Although most of the more recent reports have been cautiously optimistic (Kennedy, 1970; Taylor, 1970; British Medical Association Planning Unit Report No. 3, 1969; Ockenden and Bodenham, 1970), one (Mitchell, 1969) was distinctly pessimistic. Finance is an important limiting factor and Ockenden and Bodenham (1970) have suggested that initial investment should be concentrated on simpler batch-processing of data, rather than on the more complex and expensive real-time systems in which data are handled continuously. Successful applications of the batch-processing technique in the United Kingdom include the recording of data from patients in general practice (Gruer and Heasman, 1970), systems for the detection of thyroid disease (Barker and Bishop, 1969; Hedley et al., 1970), and the peptic ulcer project (Kennedy et al., 1968; Kennedy, 1970). Also using batch-processing and the SWITCH system (Kennedy et al., 1968), it has proved possible in the present project to store on magnetic tape the complete medical record of a hypertensive patient. Designing and running the system were made easier by the fact that hypertension is a relatively chronic disease and retrieval of information week by week rather than hour by hour is usually adequate for out-patient management. We are also fortunate in that data are collected by a relatively small group of experienced physicians who are familiar with the recording system. Most important was the existence of the SWITCH programme for patients with peptic ulcer (Kennedy et al., 1968). Several reports have made the point that medical computer projects are best developed in parallel (Taylor, 1970; British Medical Association Planning Unit Report No. 3, 1969; Ockenden and Bodenham, 1970), and this has certainly been our experience; many of the programs in our own project were the same as those used in the peptic ulcer clinic, and economies were possible because the two projects shared personnel and equipment in the Department of Medical Computing.
The practical points to emerge from this study are that it is possible to collect data in a reasonably uniform manner from hypertensive patients in four different hospitals; that a computer print-out of this information is an entirely satisfactory substitute for the traditional hospital record; that extraction of data from the magnetic tape store is feasible and that experience of the Conn’s syndrome extract suggests a way in which the screening of biochemical data by a computer could improve management of hypertensive patients.

The following played a part in establishing and running the clinics and data-processing unit—

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