MICROCOMPUTER-BASED HAEMODYNAMIC MONITORING DURING CONTINUOUS EXTRADURAL ANALGESIA

H. OWEN, G. N. C. KENNY, F. TOAL AND R. RENNIE

Although continuous extradural analgesia is the best available technique with which to provide pain relief after upper abdominal surgery (White, 1982), arterial pressure must be measured frequently, usually by nursing staff, after each injection to detect any resultant decrease in arterial pressure. Monitors are now available which can measure automatically, systemic arterial pressure accurately and non-invasively (Hutton, Dye and Prys-Roberts, 1984). They can be set to alarm when arterial pressure decreases below a pre-set limit and, in addition, can obtain measurements of arterial pressure frequently—although prolonged operation in this mode is uncomfortable and undesirable (Sy, 1981).

A system has been developed which can obtain, record and store measurements of systemic arterial pressure and heart rate. Measurements are obtained automatically and can be recorded more frequently immediately after each administration of the local anaesthetic agent or vasopressor drug, and less often during periods of greater cardiovascular stability. The system has been evaluated in a study on the cardiovascular effects of frequent small injections of bupivacaine, to the extradural space, in nine patients undergoing elective upper abdominal surgery.

PATIENTS AND METHODS

Hardware

The system (fig. 1) is based on an Apple II microcomputer with single disc drive linked to a Dinamap 1846 non-invasive arterial pressure monitor (distributed by Critikon Ltd, Broadlands, Sunninghill, Ascot, Berks, SL5 9JN) which can, in addition to conventional use through the front panel, be controlled and interrogated by the computer via an RS232 interface. A colour monitor displays a trend graph of the cardiovascular data and allows entry of the data off-line using a light pen (Madsen, Kenny and Campbell, 1983). All entries and events are timed by the computer. A permanent record is produced on a thermal printer and data are stored on a magnetic floppy disc.

Software

When the power is switched on the system checks itself and the date and time are confirmed with the operator. Details of the patient are entered via the keyboard. If data from the patient have been stored previously, the files are retrieved automatically and a coloured trend graph of arterial pressure, heart rate and rate-pressure product displayed. If a new patient is entered, the program instructs the Dinamap 1846 to take two
readings of arterial pressure and these values (baseline) are displayed. A hard copy of the display can be obtained (fig. 2).

Free text comments can be entered directly from the keyboard, although the concentration and volume of local anaesthetic agents used for maintaining extradural analgesia are entered, using the light pen, from a drug menu displayed on the screen. This greatly increases the speed and ease of documentation (Madsen, Kenny and Campbell, 1983). Selection of a local anaesthetic agent with the light pen automatically instigates measurement of arterial pressure every 5 min. The program initiates a measurement cycle by sending to the Dinamap monitor the ASCII characters "BBB" via the RS232 interface. When the characters "BBA" are transmitted, the Dinamap responds by sending to the computer at 600 baud (bits per second) a string of characters containing the arterial pressure, heart rate and time of measurement. Each new set of measurements is printed and stored on disc. The trend graph is redrawn using the new information. The systolic pressure is compared with the previous value and, if it is greater, the hypotensive effect of the "top-up" injection is decreased. Cardiovascular measurements can now be made much less often and the frequency is decreased automatically to once every 15 min until the entry of the next dose of drug. If a vasopressor drug is given, the agent and the dose can be entered (using the light pen) and this also initiates more frequent measurements of the cardiovascular indices. The light pen is used to enter details of the dermatomal spread of analgesia.

Clinical experience

To illustrate the clinical application of this system we report on nine patients (table I), receiving continuous extradural analgesia, in whom the cardiovascular variables were measured and recorded by the apparatus. In the anaesthetic room the patient was connected to the apparatus and baseline readings were obtained automatically. A standardized anaesthetic, using no opioid, was administered to all patients. An extradural catheter was introduced at mid-thoracic level and 6 ml of 0.5% bupivacaine administered before the commencement of surgery. At the end of surgery the patients were transferred to the recovery area still attached to the apparatus.

The patients were randomly assigned to receive 2, 3, 4 or 5 ml of 0.5% bupivacaine extradurally every 1.5, 2 or 2.5 h. The first dose was given when the patient had recovered sufficiently to allow determination of the limits of the block. Dermatomal spread was assessed by cold (ethyl chloride spray) and pin prick, and was repeated before and 30 min after each top-up injection. If the extradural blockade progressed or regressed the volume of local anaesthetic, or the timing of the dose, was adjusted accordingly.

RESULTS

Complete records were obtained in all patients. The duration of extradural blockade and the number of top-ups are shown in table I. After each of the 44 top-up injections the arterial pressure decreased; however, after 19 of these the systolic
pressure decreased by less than 10 mm Hg. The maximal decrease in arterial pressure was reached within 20 min (fig. 2) after all but one top-up, when it reached its minimum value after 39 min. Marked decreases in arterial pressure occurred in three patients who were sat up while the extradural blockade was still effective.

When top-ups of less than 3 ml were administered (eight doses), or the interval between top-ups was greater than 2 h (six doses), the blockade became patchy or regressed. When a volume greater than 4 ml was used (five doses), the blockade extended progressively and in both of the patients concerned the concomitant decrease in arterial pressure was prolonged. Ephedrine was given to correct hypotension after three of the 5-ml top-ups and after one other.

A top-up of 3–4 ml every 2 h was found to provide continuous analgesia which was associated with small decreases (less than 15 mm Hg) in arterial pressure in all patients. Only one patient in the study (receiving 2-ml top-ups) required additional analgesia. All patients had urinary retention for the duration of the block and in five the bladder was catheterized.

**DISCUSSION**

The system described provided records of the cardiovascular/dermatomal course of continuous thoracic extradural blockade. Cardiovascular measurements were made as often as appropriate. If measurements are too frequent, the patient suffers discomfort and ulnar paresis may ensue (Sy, 1981). Yet, if measurements are made infrequently, episodes of arterial hypotension may go unrecognized.

We have shown that frequent small bolus injections of local anaesthetic to the extradural space can provide continuous stable blockade. Arterial hypotension after small incremental doses (4 ml or less) was not a significant problem, but it did occur (see fig. 2), and probably prohibits the use of automatic extradural injection devices (Cox and Spoerel, 1964) on the general ward unless there is guaranteed haemodynamic monitoring. When top-ups are administered regularly, the patient does not have a painful interval between increments and tachyphylaxis is less likely (Bromage, Pettigrew and Crowell, 1969). If the
incremental injections are either too large or too small, the block may extend or regress. This is readily apparent from the print-out of dermatomes and the volume injected can be adjusted as required.

Our apparatus has been used only in a well-staffed recovery room, but could be used for the routine haemodynamic monitoring of extradural blockade. It is not seen as an alternative to skilled observation, but time currently spent measuring and recording heart rate and arterial pressure could be used to attend to the patient’s needs.

The use of a light pen to make entries from menu pages on the monitor has made the system simple to use and removes the need to use the keyboard. Nursing staff have appreciated the ability of the system to document cardiovascular changes automatically.

The Dinamap 1846 had a timing circuit to prevent overlong cuff inflation. However, this safety feature would be overridden if the computer were to send a continuous string of “BBB”. Our program has been constructed to avoid this possibility. Computer control does not impinge on any other feature of the device. Unlike previous models, the heart rate and arterial pressure are stored by the Dinamap 1846 until the computer requests the transmission of data. Interrupt routines or custom-built interfaces are unnecessary; however, the computer must interrogate the Dinamap frequently to determine whether a measurement cycle has been completed and whether new data are available.

The system we have described can be assembled from readily available proven equipment and can provide a useful tool for the safer haemodynamic monitoring of patients undergoing continuous extradural analgesia.

ACKNOWLEDGEMENTS

The authors wish to thank Professors D. C. Carter and D. Campbell for their help in facilitating this study.

REFERENCES


