

invasive techniques were unsuccessful, but the Doppler method measured blood pressures consistently in the range of 90 to 100 torr systolic throughout the procedure.

This representative group of infants illustrates the manner in which Doppler blood pressures may be of value. On several occasions, blood pressure information vital to safe anesthetic and surgical management was obtained when it was impossible to achieve these measurements by other noninvasive techniques. On occasions not mentioned in this report, when Korotkoff determinations were available, there was close correlation with the Doppler measurements. In a recent review of pediatric anesthesiology, Rackow and Salanitre concluded by noting: "We still lack a simple, reliable way of measuring blood pressure in the small infant."⁵ With the instrumentation presently available, we feel that we may now determine blood pressure in infants under con-

ditions in which it is unobtainable by other noninvasive methods.

REFERENCES

1. Kirby RW, Kemmerer WT, Morgan JL: Transcutaneous Doppler measurement of blood pressure. *ANESTHESIOLOGY* 31:86, 1969
2. Morgan JL, Kemmerer WT, Halber MC: Doppler shifted ultrasound: History and applications in clinical medicine. *Minn Med* 52:503, 1969
3. Stegall HF, Kardon MB, Kemmerer WT: Indirect measurement of arterial blood pressure by Doppler ultrasonic sphygmomanometry. *J Appl Physiol* 25:793, 1968
4. Ware RW, Laenger CJ, Heath CA, et al: Development of indirect blood pressure sensing technique for aerospace vehicle and simulator use. Technical Report AMRL-TR-6F-201, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio, 1968
5. Rackow H, Salanitre E: Modern concepts in pediatric anesthesiology. *ANESTHESIOLOGY* 30:208, 1969

Self-administration of Intravenous Analgesics

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An instrument that safely administers analgesic drugs intravenously when a patient feels the need and can be activated by his pressing a button or similar device may have clinical and research application, particularly in the management and investigation of postoperative pain. Small doses of analgesia given intravenously can provide rapid, safe pain relief. The intravenous approach may avoid some of the disadvantages and hazards which are present when larger doses are given by other parenteral routes. A patient-activated system would ensure instantaneous analgesic medication at times of peak pain intensity.

Patient-activated systems, in which a series of gas-driven electronically-controlled pistons inject into the patient's infusion line a fixed

volume of analgesic solution, have been described by other workers.¹ A new apparatus (Demand Dropmaster), which automatically dispenses intravenous analgesic drugs on demand has been developed for use at the Veterans Administration Hospital, Palo Alto, as a part of the VA Cooperative Analgesic Study. Built by Corbin Farnsworth and designed in conjunction with one of the authors (WHF), the system uses a gravity-feed principle whereby drug-containing solutions may be fed into a maintenance infusion line. The device is composed of two interconnected units. The master unit, stationed outside the room, controls and monitors infusion rates and drug doses. The small bedside unit further regulates intravenous fluid flow. The design concept is fail-safe.

An infusion stand supports a maintenance infusion bottle (M.I.B.) and the analgesic infusion bottle (A.I.B.). The tubing from the M.I.B. passes through a solenoid valve on the bedside unit (fig. 1). The tubing from the A.I.B. passes through its appropriately num-

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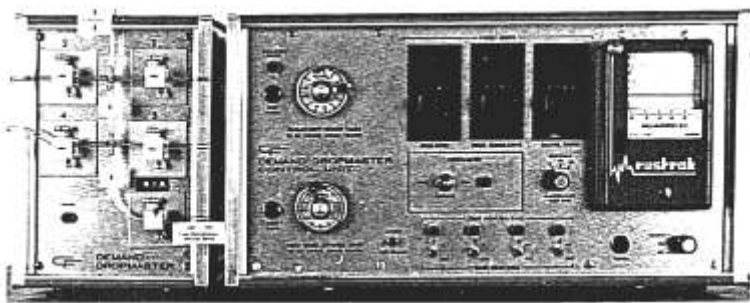


FIG. 1. The two units of the dropmaster system. On the right is the larger control unit. The smaller unit, on the left, shows a solenoid valve marked M.I.B. This controls the maintenance infusion stream. The valves numbered one to four permit the entry of any one of four drug-containing solutions into the maintenance infusion stream. Arrows indicate the direction of flow.

bered solenoid valve and is then connected to the maintenance infusion stream. The drip chamber of each infusion set is clamped by a photoelectric drop sensor which is connected to the bedside unit, thereby establishing an electrical circuit between each photoelectric cell and the solenoid valve through which the tubing must pass. This portion of the system guarantees accurate delivery of predetermined amounts of solution.[§]

The larger unit houses the Rustrak recorder and the bulk of the controls. The control panel of the larger unit is shown in figure 1. It comprises:

- 1) Power on-off and record switch.
- 2) Knob to select M.I.B. drop rate of 2, 20, or 50 drops per minute.
- 3) Three totalizers which can be preset and locked: a) Drug dose. This totalizer is set to determine the number of drops from the A.I.B. to be dispensed per patient request; b) Drug cumulative. This totalizer is set to stop the delivery from the A.I.B. when the total number of drops accumulated with repeated doses reaches the number on the totalizer; c) Saline flush. This totalizer is set to deliver a predetermined amount from the M.I.B. to flush the system after each bolus from the A.I.B.
- 4) Alarm reset switch marked "Start-Run."

[§] The gravity-feed system had already been developed by Corbin Farnsworth and has been used in obstetrics to deliver oxytocics during labor.

5) Refractory period timer. This timer is set to the desired duration of the refractory period. It is adjustable between two minutes and one hour. During the refractory period, patient requests for drug do not actuate the system (except for the recorder).

6) Auto-drug-change time. The apparatus can dispense as many as four different drugs in sequence. The time spent on each drug is adjustable between ten minutes and five hours. At the end of this period of time, the patient is switched to the next A.I.B. in the system. Any one of the four drug valves can be manually switched in or out of the dosing sequence.

7) Recorder. The Rustrak Recorder registers the drug currently in use. Within each of the four drug channels on the strip chart, the recorder produces a continuous record in one of three columns corresponding to the mode the machine is in at that time: a) The refractory period; b) Ready to dispense a drug when requested; c) Delivery of drug. A fourth column within each drug channel records drug requests made during the refractory period.

When the apparatus is in use, it is capable of delivering up to four medications serially. For simplicity and clarity of description, the delivery of only one drug solution will be described. The maintenance infusion runs at a slow preset rate to keep the infusion line

open. To make a drug request, the patient presses a button on a hand grip, which activates the system to dispense a preset number of drops from the A.I.B. When this bolus has been delivered, the system reverts to the M.I.B., but the delivery rate remains high until the preset number of drops of flush from the M.I.B. is reached. The bolus of drug is thereby flushed through the intravenous tubing into the patient. The system is now refractory to patient request, and no drug will be dispensed until the refractory period expires or the timer is manually reset.

The following safety factors have been designed into the system: 1) A drug will be dispensed only when requested by the patient; 2) The solenoid valves which control the flow of fluids into the patient are closed in the resting state; in the event of power failure, the valve shuts; 3) The refractory period minimizes the risk of too-frequent self-administration of drug; 4) When the total dose measured in drops from the A.I.B. equals the set-

ting on the totalizer marked "drug cumulative dose," the system stops and alarms; 5) An alarm rings, and the valves close, if the line is blocked for more than 30 seconds. The alarm must be manually reset before drug dose can resume. The ultimate safety factor to avoid drug overdose resides in the volume of drug available to enter the system. We have used Abbot's Solusets on the A.I.B., and we place only safe total doses of analgesic in the chamber at any one time.

The eventual utility of the Demand Drop-master in clinical medicine and/or research in clinical pharmacology will be determined by its patient and physician acceptance and its fail-safe capability. Our experience in pilot studies has been quite satisfactory. Patient and physician acceptance has been good, and the fail-safe features reliable, in 30 experiments.

REFERENCE

1. Sechzer PH: Objective measurement of pain. *ANESTHESIOLOGY* 29:209, 1968.

A Method of Venipuncture in Patients with Peripheral Edema

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In patients with subcutaneous edema, puncture of peripheral veins often proves to be uncertain and troublesome. The veins may be invisible and nonpalpable even after the

placement of a tourniquet, and venipuncture is often attempted as a blind procedure.

The authors have developed a simple and useful technique for venipuncture in patients with peripheral subcutaneous edema.

Figure 1 shows an edematous leg with no visible veins, with a tourniquet in place. To

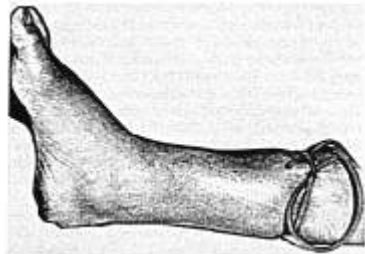


FIG. 1. A tourniquet is in place, but no vein is visible.

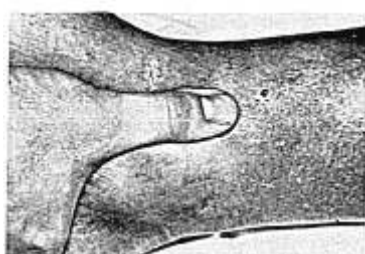


FIG. 2. Firm pressure is exerted on the skin where a vein is expected to be.

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