PATIENT-CONTROLLED ANALGESIA I: HISTORICAL PERSPECTIVE AND NEWER DEVICES

P. F. White

In designing patient-controlled analgesia (PCA) equipment, biomedical engineers have utilized negative feedback control technology. When feedback control is applied to the control of pain, the patient self-administers analgesic medication to decrease the error signal (i.e., the difference between the pain experienced and the acceptable (tolerable) level of pain) to zero (1,2). PCA techniques attempt to close the feedback loop without the necessity of nursing staff intervention, thereby, improving the effectiveness of the pain control system.

Since the first widely used PCA device was introduced into clinical practice in the United Kingdom in 1976, several more technologically advanced PCA delivery systems have been introduced in the United States. The major advantages of these newer PCA systems relate to their computerized programming features and fail-safe designs. This chapter will describe some of the important features of PCA systems which have been developed over the last twenty years.

HISTORICAL PCA INFUSION DEVICES

The Cardiff Palliator™ (Graseby Dynamics) is a line-powered syringe pump which can be preprogrammed to deliver the desired dose of medication at a predetermined flow rate with a preselected minimum dose interval. The parameters are adjustable over a wide range to accommodate a variety of drugs and dosage regimens. To minimize the possibility of the button being pressed accidentally, the button must be pressed twice in rapid succession (within 1 s) to achieve a successful demand. A disposable 20 ml syringe can be filled with the analgesic of choice. A yellow indicator lamp (which remains on during the
lockout interval) and a tone sounds when a bolus dose is successfully infused. An audible alarm sounds whenever the syringe is empty. The thumbwheel switches are accessible on the front and rear of the device for controlling the incremental dose (range 1-999 mg), dilution control (range 1-99 mg/ml), interval time (range 1-99 min), and delivery rate (range 1-99 ml/hr). Unfortunately, these thumbwheel switches are not tamperproof and therefore the settings had to be frequently monitored. A “second generation” Cardiff Palliator containing the safety and security features present on the more recently developed PCA devices will be available for clinical use in the near future.

The Pharmacia Prominject™ pump is a microprocess controlled, programmable infusion pump with three different modes of operation (namely, patient-controlled, consecutive infusions, and constant infusion). The consecutive infusion mode allows for the administration of a loading dose (“priming” infusion), followed by a constant maintenance infusion. This device is also capable of delivering split incremental doses (e.g., a bolus dose delivered over 1 min followed by an infusion of the equivalent dose over 1 hr). After selecting the desired operational mode, the operator enters the drug concentration, dose, lock-out interval (in PCA mode), and time for infusion of the dose. The alphanumeric message panel guides the operator step-by-step through the programming procedure. The prescribed drug is delivered from a standard 20 ml B-D luer lock disposable syringe which is covered by a clear tamper-proof perspex cover. This cover is locked with a key which also electronically locks the keyboard. A hard copy of the drug usage record is produced by a built-in dot matrix printer. The time, date, and accumulated dose are printed simultaneously with the event or retrospectively from the microprocessor memory. Acoustic and diagnostic alarms and status messages will report line occlusion, empty syringe, low battery charge, and improper program settings. The device can be mounted on an infusion stand or placed on a table top.

The On Demand Analgesia Computer (ODAC™, Janssen Scientific Instruments) is a highly innovative experimental PCA device. This infusion device allows the patient to interact directly with the machine using a tape cassette. In addition to demand doses, this device can administer a background infusion based on the amount of analgesic drug which the patient demanded during the previous 16-minute interval. An integral pneumograph sensor prevents analgesic administration if the respiratory rate is depressed. With further technological refinement, the ODAC™ could become a clinically useful