and was breathless when she stooped. Since having been buried for several hours after bombing during the war she had suffered from claustrophobia, and her symptoms were thought to be due to anxiety. On examination she had no abdominal paradox, but investigations showed pronounced diaphragm weakness. Transdiaphragmatic pressure was 38 cm H₂O during a maximal sniff, 17.5 cm H₂O during a maximal inspiration, and 6 cm H₂O during a maximal static inspiratory effort. This patient had autoimmune disease with a history of Hashimoto's thyroiditis, systemic sclerosis, and Raynaud's disease.

Comment

Patients with complete paralysis of the diaphragm are known to complain of dyspnoea and gross orthopnoea. Examination of the patient in the supine position shows paradoxical inward inspiratory motion of the anterior abdominal wall.³ By contrast, patients who have mild weakness of the diaphragm may complain of shortness of breath only during exertion and often do not have orthopnoea or paradoxical abdominal motion.⁵ As a result, diaphragm weakness may not be suspected clinically, and the symptoms may be considered to be psychogenic unless transdiaphragmatic pressures are measured.

Patients with moderate diaphragm weakness can usually breathe comfortably when standing. During expiration they contract the abdominal muscles, thereby pushing the abdominal contents up into the chest and raising the diaphragm. During inspiration descent of the weak diaphragm is assisted by the downward action of gravity on the abdominal contents. When patients are immersed in water above the abdomen, however, the additional weight of water prevents adequate abdominal expansion and thus descent of the diaphragm, resulting in dyspnoea. Diaphragm weakness should be considered in any patient who complains of inability to breathe when standing in deep water.

A Mier is supported by the Medical Research Council and Conor Brophy is supported by Napp Laboratories.

- 1 Agostoni E, Rahn H. Abdominal and thoracic pressures at different lung volumes. *J Appl Physiol* 1960;15:1087-92.
- 2 Miller J, Moxham J, Green M. The maximal sniff in the assessment of diaphragm function in man. *Clin Sci* 1985;69:91-6.
- 3 Newsom Davis J, Goldman M, Loh L. Diaphragm function and alveolar hypoventilation. *Q J Med* 1976;45:87-100.
- 4 DeTroyer A, Estenne M. Limitations of measurement of transdiaphragmatic pressure. *Thorax* 1981;36:169-74.
- 5 Mier A, Brophy C, Moxham J, Green M. Diaphragm weakness and orthopnoea. *Thorax* 1985;40:631-2.

(Accepted 19 March 1986)

Brompton Hospital, Fulham Road, London SW3

ANNE K MIER, MRCP, research registrar
CONOR BROPHY, MRCP, research registrar
MALCOLM GREEN, DM, FRCP, consultant physician

Correspondence to: Dr Mier.

New portable infusion pump for prolonged subcutaneous administration of opioid analgesics in patients with advanced cancer

Pain associated with advanced cancer is well controlled with oral medication in most patients. For those unable to take drugs by mouth continuous subcutaneous infusion of opioid analgesics using a portable syringe driver has become an established technique.^{1,2} In Britain the Graseby Dynamics MS series syringe drivers are the most widely used and are usually reprimed every 24 hours.³ We have investigated a new portable infusion device which can be set to run for up to 37 days without repriming.

Materials, methods, and results

Act-a-Pump (Pharmacia) is a peristaltic pump housed in a rigid container measuring 9.5×3.8×10.5 cm and weighing 425 g (figure). It has a 75 ml disposable reservoir and can deliver drug solutions at flow rates of 2-110 ml/24 h. The flow rate is set by a separate flow rate meter. The device is powered by a rechargeable battery pack and, as with the Graseby syringe drivers, can be worn in a shoulder holster pouch or on a belt. Its main use at present is for continuous infusions of cytotoxic chemotherapy.

Diamorphine is preferred to morphine for parenteral administration in patients with cancer because it is much more soluble. A concentration of 250 mg

diamorphine/ml (25% wt/vol) is a convenient maximum for continuous infusions.⁴ Few patients will need more than 2 ml (500 mg) a day.

Stability of diamorphine—Freeze dried diamorphine hydrochloride for injection is usually prepared immediately before use and discarded after 12 or 24 hours in the interests of sterility. This practice is widely misperceived to have been based on the limited chemical stability of diamorphine in aqueous solution. We investigated the stability of diamorphine in the device over two weeks while it was being worn by a healthy volunteer. The concentrations of monoacetylmorphine and morphine, the main breakdown products of diamorphine, together represented less than 1% of the final concentration of diamorphine (as measured by high performance liquid chromatography⁵). The solution of diamorphine was made up under sterile conditions in the pharmacy, and laboratory examination over the two weeks showed no bacterial contamination.

Clinical use—We have accumulated a total of 407 days' use of the pump in four patients. Two patients found it so convenient that we decided not to take it from them to try in others. Both were outpatients: one used it continuously for seven and a half months and had it reprimed by a district nurse once a fortnight using a ready filled reservoir made up in the local hospital pharmacy; the other used the pump for four months. We have had one pump failure (after six months continuous use) and one incident of leakage from poorly connected tubing.

New portable infusion pump.

Comment

In hospital practice repriming syringe drivers presents no difficulty, but for patients at home a daily visit from the district or specialist nurse would usually be necessary. Patients receiving continuous opioid infusions are usually ill and in need of close supervision, so that a daily visit may in any case be required. For these patients, the majority, syringe drivers will be preferred. Some patients, however, will not need frequent visits, and for them the present device has definite advantages. Our two outpatients much preferred it to the syringe driver.

The Act-a-Pump infusion system remains completely closed between reprimings. This has meant fewer changes of the infusion site for our patients, presumably because of a lesser tendency to cause subclinical infection or inflammation. Disadvantages of the pump are its bulk and weight and the complexity of setting it up compared with syringe drivers.

Administration of opioids, which are not as soluble as diamorphine, will be easier with Act-a-Pump because of its large reservoir. This may enable the technique of continuous subcutaneous infusion to be used more widely outside Britain than at present.

We thank Simon Joel, of the ICRF Department of Medical Oncology, Hackney Hospital, for the high performance liquid chromatography analyses and the pharmacy staff at the Royal Marsden Hospital for their help and enthusiasm. We also thank the Institute of Cancer Research and the Campbell Paterson Fund for financial support. VAJ is supported by the Sir Halley Stewart Trust.

- 1 Russell PSB. Analgesia in terminal malignant disease. *Br Med J* 1979;ii:1561.
- 2 Oliver DJ. The use of the syringe driver in terminal care. *Br J Clin Pharmacol* 1985;20:515-6.
- 3 Wright BM, Callan K. Slow drug infusions using a portable syringe driver. *Br Med J* 1979;iii:582.
- 4 Jones V, Murphy A, Hanks GW. Solubility of diamorphine. *Pharmaceutical Journal* 1985;235:426.
- 5 Svensson JO, Rane A, Sawe J, Sjoquist F. Determination of morphine, morphine-3-glucuronide and (tentatively) morphine-6-glucuronide in plasma and urine using ion-pair high performance liquid chromatography. *J Chromatogr* 1982;230:427-32.

(Accepted 17 April 1986)

The Royal Marsden Hospital, London SW3 6JJ

VALERIE A JONES, BSC, SRN, research sister
G W HANKS, BSC, MRCP, consultant physician

Correspondence to: Dr Hanks.