13. Barber C: Evoked Potentials. Lancaster, MTP Press, 1980
14. Harding GFA: The visual-evoked response. Adv Ophthalmol 28:2–28, 1974
15. Kreyszig E: Statistische Methoden und ihre Anwendungen. Göttingen, Vandenhoeck und Ruprecht, 1975, pp 239–257
16. Borda RP: Visual evoked potentials to flash in the clinical evaluation of the optic pathways, Visual Evoked Potentials in Man. New Developments. Edited by Desmedt JE. Oxford, Clarendon Press, 1977, pp 481–489
17. Greenberg RP, Ward JD, Lutz H, Miller JP, Becker DP: Advanced monitoring of the brain, Brain Failure and Resuscitation. Edited by Grenvik A, Safar P. New York, Churchill Livingstone, 1981, p 84
18. Russ W, Lüben V, Hempelmann G: Der Einfluß der Neuroleptanalgesie auf das visuelle evozierte Potential (VEP) des Menschen. Anaesthesist 31:575–578, 1982
19. Uchida T, Suzuki N: Origin of the secondary response induced by flash stimulation under barbiturate anesthesia in the rabbit. Jpn J Physiol 27:399–411, 1977
20. Cohn R, Rosomoff HL: Evoked cerebral activity of the brain during hypothermia. Arch Neurol 80:554–561, 1958
21. Nogoa S, Roccaforte P, Moody A: The effects of isovolemic hemodilution and reinfusion of packed erythrocytes on somatosensory and visual evoked potentials. J Surg Res 25:530–537, 1978
22. Davis FM, Parimelazhagan KN, Harris EA: Thermal balance during cardiopulmonary bypass with moderate hypothermia in man. Br J Anaesth 49:1127–1132, 1977
23. Muravchick S: Deep body thermometry during general anesthesia. ANESTHESIOLOGY 58:271–275, 1983
24. Withby JD, Dunkin LJ: Cerebral, esophageal and nasopharyngeal temperatures. Br J Anaesth 43:673–676, 1971

Anesthesiology
61:210–212, 1984

Epidural Morphine Analgesia in Children

LEV A. SHAPIRO, M.D.,* ROBERT J. JEDEIKIN, M.B., CH.B., F.F.A. (S.A),† DANIEL SHALEV, M.D.,* SEYMOUR HOFFMAN M.B., CH.B., M.MED. (S.A)‡

Epidural blockade in children has not received wide acceptance as a mode of anesthesia and analgesia. Successful postoperative analgesia with epidural blockade in the pediatric age group has been achieved by Russian clinicians.[1–3] In a series of 220 pediatric patients, Parnes *et al.*[2] found epidural injection easy to perform and observed an improvement in respiratory and cardiac function postoperatively.[2] Recently Katzenelson *et al.*§ described similar experiences with caudal opiates in children. No reports have been published describing lumbar or thoracic epidural narcotic analgesia in children. We describe five children who received thoracic epidural morphine for analgesia after surgery and trauma.

REPORT OF FIVE CASES

Five children, aged between 3 and 11 years, were admitted to the Intensive Care Unit (ICU) with thoracic epidural catheters in place for analgesia. Four of them had thoracic surgery, with the epidural catheters inserted at the end of surgery while still receiving general anesthesia (table 1). The fifth patient, a child with multiple trauma, which included flail chest, pneumothorax, and fractures of the humerus and femur, was admitted to the ICU after having undergone a laparotomy for a ruptured spleen. Ventilation was controlled for the first 6 h after surgery, after which his trachea was extubated and an epidural catheter was inserted under local analgesia. The four postthoracotomy patients breathed satisfactorily at the end of surgery, their tracheas extubated, and they received oxygen ($F_{I_{O_2}} = 0.4$) via a mask for 3 h.

Morphine 1.0–2.0 mg diluted in 5 ml normal saline was injected into the thoracic epidural space (table 2). Every hour the children were instructed to cough, take several deep breaths, and lift their legs off the bed where possible. They were asked if they had pain, and when pain was confirmed, whether they wanted to be relieved of the pain. Additional doses of morphine thus were administered at the request of the patient. We found this method simple to use, all five children including the youngest being cooperative. Because of being in the ICU, we were able to inject the morphine epidurally as soon as pain returned and document the duration of analgesia. The three children under seven years of age received 1.0 mg in 5 ml of saline, while the 8-year-old was given 1.5 mg and the 11-year-old 2 mg in 5 ml saline. The analgesia following the initial dose of morphine lasted between 8 and 25 h (table 2). Additional doses of morphine in the three older children were the same as the initial dose. However, in the first patient, a 3-year-old child, we decreased the subsequent dose

* Tutor and Senior Anesthesiologist.
† Lecturer and Director Intensive Care Unit.
‡ Head of Department and Senior Lecturer.
§ Presented at the 6th European Congress of Anaesthesiology, London, September 8–15, 1982.

Received from the Department of Anesthesiology and Intensive Care, Meir General Hospital, Kfar Sava and Sackler School of Medicine, Tel Aviv University, Israel. Accepted for publication January 19, 1984.

Address reprint requests to Dr. Shapiro: Department of Anesthesia, Hasharon Hospital, Petah Tikvah, Israel.

Key words: Anesthesia: pediatric. Analgesics: morphine. Analgesia techniques: epidural morphine. Pain: postoperative.

TABLE 1. Age, Diagnosis, Type of Surgery and Level of Insertion of Epidural Cannula in Five Children

Patient	Age (yr)	Diagnosis	Operation	Level of Epidural Cannula Insertion
1	3	Bronchiectasis	Left thoracotomy and left lower lobectomy	T_{7-8}
2	5	Bronchiectasis	Left thoracotomy and left lower lobectomy	T_{4-5}
3	7	Multiple trauma including hemopneumothorax and flail chest	Laparotomy, splenectomy. Radial and brachial artery exploration. Fixation of fractures of left humerus and left femur	T_{7-8}
4	8	Thymoma	Right thoracotomy, thymectomy	T_{7-8}
5	11	Coarctation of the aorta	Left thoracotomy and repair of coarctation	T_{5-6}

to 0.5 mg morphine in 5 ml saline. This smaller concentration of morphine provided analgesia for only 4 h, after which a further injection was required. Morphine, 1.0 mg, administered to the second patient (5-year-old child) resulted in 8 h of analgesia, while a 1.5-mg subsequent dose resulted in a further 24 h of analgesia.

Epidural catheters remained in place from 2 to 5 days. There were no complications that could be attributed to the administration of morphine into the epidural space. Analysis of arterial blood gases indicated no evidence of respiratory depression 24 h following the epidural blockade.

DISCUSSION

Epidural morphine is a useful method to provide analgesia.[4-6] We believe that there is no reason why children should not be able to enjoy the advantage of this method. In this pilot study of five children, our first major problem was that of establishing an appropriate dose schedule according to age or size. Bromage[7] found that in children younger than 10 years of age, the epidural requirements of local anesthetic were unpredictable. We had found that in adults, 4 mg of morphine diluted in 10 ml of saline gave satisfactory analgesia with a minimum of side effects.[5] Using our adult dose as a guide, we decided on a total volume of 5 ml saline, varying the morphine content according to the age.

On the basis of the analgesia obtained in our cases (table 2), we suggest the following dose schedule, which at this stage appears satisfactory and safe: Children ages 3–7 yr to receive 1 mg; ages 7–10 yr to be given 1.5 mg, and ages 10–13 yr to receive 2 mg. The total volume injected should not exceed 5 ml and the subsequent dose probably can be the same as the initial dose, unless the response suggests otherwise.

The prevention of pain is much simpler to achieve than the treatment of pain when once established. Therefore, when possible, as in the four children who underwent elective surgery, morphine should be injected at the end of the operation prior to the end of general anesthesia and the onset of pain.

In all five children, analgesia was considered satisfactory, lasting from 2 to 5 days. The nursing staff found the children easy to manage, and physiotherapy was facilitated. All four nontrauma patients were walking about the unit less than 24 h postoperatively.

Parnes *et al.*[1,2] and Isakov *et al.*[3] found that insertion of an epidural catheter in children was exceptionally easy

TABLE 2. Dose of Epidural Morphine and Duration of Blockade

Patient	Initial Dose of Morphine in 5 ml Saline	Duration of Analgesia (h)	First Subsequent Dose of Morphine in 5 ml Saline	Duration of Analgesia (h)
1	1 mg	22	0.5 mg	4
2	1 mg	8	1.5 mg	24
3	1 mg	25	1 mg	10
4	1.5 mg	11	1.5 mg	8
5	2 mg	18	2 mg	21

TABLE 3. Respiratory Rate and Analysis of Arterial Blood Gases Measured during First 24 Hours after Surgery

		Three Hours Postoperatively*		Following the First 24 Hours†	
Patients	Respiratory Rate (breaths/min)	Pa_{O_2} (mmHg)	Pa_{CO_2} (mmHg)	Lowest Level Pa_{O_2} (mmHg)	Highest Level Pa_{CO_2} (mmHg)
1	Between 28–32	87.6	36.2	60.1	40.4
2	Between 24–28	86.0	39.2	82.0	39.3
3	Between 24–28	118.2	32.7	99.7	36.5
4	Between 20–24	105.3	50.0	80.0	36.2
5	Between 28–36	110	34.6	92.6‡	36.0

* FI_{O_2} = 0.4.
† FI_{O_2} = 0.21.
‡ FI_{O_2} = 0.3.

to perform. They attributed this to the increased elasticity of soft tissue as well as the enlarged epidural space in children, especially in the thoracic region. We similarly found epidural cannulation simple to perform in our young patients. Unlike local anesthetic epidural analgesia, there is no fear of a sympathetic nerve block when using morphine. However, as rostral spread and respiratory depression have been reported by Bromage *et al.*,[6] we kept all five children in the ICU, where respiratory rate and tidal volume routinely were measured every hour and blood gases monitored every 2–4 h (table 3). No signs of respiratory depression were observed. Although we only studied five children, we were most encouraged by the excellent response to morphine epidural analgesia, however, we feel that further comparative studies should be undertaken in order to establish what place this technique eventually will take in the management of postoperative analgesia in children.

References

1. Parnes DI, Gordeev VI: Some indices of external respiration in conduction of the postoperative peridural anaesthesia in children. Vestn Khir 105:66–69, 1970
2. Parnes DI, Tsibuljkin EK, Gordeev VI, Monashkin EA, Kanaeva MA, Kostjuchenko AL: Haemodynamics and respiration in the postoperative peridural blockade in children. Vestn Khir 106:100–115, 1971
3. Isakov YF, Geraskin VI, Kozhevnikov VA: Long term peridural anaesthesia following surgery on the organs of chest in children. Grudn Khir 13:104–109, 1971
4. Behar M, Magora F, Olshwang D, Davidson JT: Epidural morphine and treatment of pain. Lancet 1:527–528, 1979
5. Shapiro LA, Hoffman S, Jedeikin RJ, Kaplan R: Single injection epidural anaesthesia with bupivacaine and morphine for prostatectomy. Anesth Analg 60:818–820, 1981
6. Bromage PR, Camporesi E, Chestnut D: Epidural narcotics for postoperative analgesia. Anesth Analg 59:473–480, 1980
7. Bromage PR: Aging and epidural dose requirements. Br J Anaesth 41:1016–1022, 1969