EPIDURAL ANAESTHESIA IN PAEDIATRIC SURGERY PRESENT STATUS IN THE HAMILTON GENERAL HOSPITAL

F G RUSTON, M D

THE USE OF epidural anaesthesia in paediatric surgery has been described in two previous reports^{1 2} It is the purpose of the present paper to report our experience with this technique in the Hamilton General Hospital since these previous publications, to demonstrate why we feel that this technique has a definite place in paediatric anaesthesia, and to endeavour to erase some of the doubts which have led to the statement in regard to anaesthesia for pyloromyotomies that "the use of epidural anaesthesia remains unconvincing"⁴

The anatomy and physiology of the epidural space have been well described by Bromage,³ and will not be repeated here Techniques, drugs, dosage, complications, and application will be discussed, with reference to operations handled by the staff in anaesthesia of the Hamilton General Hospital during the period from 1956 to 1962 inclusive

TECHNIQUE OF EPIDURAL BLOCK

Epidural block may be employed in either a single dose or a continuous technique Either may be used alone, or combined with general anaesthesia by the inhalation or intravenous routes Premature and young infants are awake when the block is given, as also are older infants and children if they have intestinal obstruction These latter may receive a sedative dose of thiopentone sufficient to pacify them without abolishing the glottic reflex Large infants and children are intubated under anaesthesia with thiopentone and a small dose of succinylcholine and are maintained on nitrous oxide, to which 0.25 per cent halothane may be added, using a non-rebreathing valve technique This general anaesthesia is induced before the epidural block is done in order to ensure the airway during prolonged surgery

The single-dose method is used for prematures and neonates, and for other infants and children when the surgical time is expected to be under two hours The infants, who are awake, are held in a sitting position, with the head supported and the elbows and knees grasped by the assistant, so that the spine is gently flexed Only slight wriggling movement can occur, which is not too troublesome All others are held in the lateral position Before the infant is positioned, the desired dose of local anaesthetic solution is drawn up into a syringe The dose in cubic centimetres equals $\frac{1}{2}$ (weight in pounds) + $\frac{1}{2}$ or 1 c.c. Usually a skin wheal is raised over the site of puncture—L2 and 3, or L3 and 4 The needle is equipped with projections which aid in placing and maintaining it in position while the injection is being made A two-inch No. 22 gauge Becton, Dickinson Epidural Needle with a Wagner Point⁵ is preferred I also prefer the hanging drop test to identify the epidural space It is positive in 85

per cent and, in spite of an occasional false positive which is mentioned by Biomage,³ which will be evident by the greatly increased resistance on the plunger when one tries to carry out the injection, it is by far the most reliable test. However, if the drop is not sucked in or does not fluctuate, then the loss of resistance on the plunger of the syringe will identify the space. Of course one must be sure, at this point, that the dura has not been pierced. If fluid escapes from the needle, let a few drops fall on the bare wrist. If these drops are cold, the dura has been spared and it is safe to inject the full dose. The patient is placed on a padded board and securely wrapped with a flannel bandage. Patients are closely observed, blood pressures are taken if it is feasible, but experience has shown that pulse, heart sounds, breath sounds, and colour are pretty reliable signs. Within five minutes definite abdominal relaxation is present, while the feet can still be moved when stimulated. (This indicates that there is not spinal anaesthesia.) Surgery can be started within five to ten minutes.

The continuous technique is reserved for large infants and children when the surgical time is expected to exceed two hours. The limiting factor is the size of the needle which will go through the interspinous space and still carry the catheter. For this reason I have not attempted to use the Tuohy Needle with the Huber Point. I have found that the thin-walled No. 18 Becton, Dickinson Needle with the short-bevel Crawford Point can be used in infants over three months of age. The patient is usually intubated as mentioned before, and held in the lateral position. After preparation, the skin is incised with a scalpel blade at the site of puncture. The needle is inserted and angled as much as possible cephalad with the bevel in the same direction. When the epidural space is entered, two cubic centimetres of solution are injected in order to act as a cushion against the needle point and to produce a space for the catheter to advance and curve cephalad from the needle point. The vinyl-tubing catheter is advanced the length of the stylette and two centimetres further, with the inner curve of the catheter cephalad. If the catheter seems to meet an obstruction, the needle is withdrawn a millimetre or two while at the same time gentle pressure is exerted on the catheter. The needle is then carefully withdrawn so that the catheter is not disturbed. A small dressing is placed over the entry site and the catheter is securely taped to the back with adhesive. The distal end of the catheter is fitted with a hypodermic needle and the total dose is given at once or in divided doses. The initial drug may be Carbocaine 1.5 per cent followed by 2 per cent Nesacaine as required. The usual supervision is maintained and an attempt is made to anticipate the waning of relaxation and anaesthesia so that additional increments of solution may be injected.

Pre anaesthetic sedation may or may not be given. Usually nothing is ordered for premature and newborn infants, "pylorics" receive Sodium Luminal gr $\frac{1}{4}$ with atropine gr $\frac{1}{600}$ intramuscularly 1 hour preoperatively, others, who have intravenous cut-downs running, receive atropine only in suitable dosage.

APPLICATION

Table I shows what was done in Hamilton from 1949 to 1956 and is from a previous report published in 1957.² It gives some idea of the scope of paediatric

TABLE I
LUMBAR EPIDURAL AND CAUDAL ANAESTHESIA, 1949 TO 1956 (80 CASES)

Condition or operation	Number	Age
Pyloric stenosis	34	3 to 8 weeks
Volvuli (1 resection of 16 in small bowel)	2	3 to 5 months
Intussusceptions (2 resections)	7	3 months to 2½ years
Splenectomy (purpura)	2	5 and 7 years
Perforated appendices (gen peritonitis)	4	2 to 4 years
Agenesis (exploration of biliary system)	1	5½ months
Meconium peritonitis, multiple volvuli (exploratory laparotomy)	2	1 day, 1 premature (under 3 lb)
Duodenal atresias (anastomosis)	2	1 week and 6 months
Jejunal atresias	2	24 hours
Biopsy of hepatic tumour	1	6½ months
Excision of large ovarian dermoid	1	23 months
Irreducible intussusception (ileotransversecolostomy)	1	5 months
Colectomy (in same patient)	1	11 months
Congenital absence of terminal portion of ileum (anastomosis of ileum to ileum)	1	2 days
Combined cystoscopy and exploration of upper ureter	1	7 years
Inguinal hernias (2 bilateral repairs, 2 strangulated)	8	2 weeks to 2½ years
Umbilical hernias (1 large 1 omphalocele with excision of accessory lobe of liver)	2	60 hours and 15 months
Congenital dislocation of hip (shelf op)	1	3 years
Tuberculosis (hip fusion)	2	6 and 7 years
Lumbar meningocele postoperative (shunt op sub-arachnoid space to peritoneal cavity)	1	6 weeks
Caudal anaesthesia		
Acute retention, phimosis (circumcision)	1	11 years
Anal fistula	1	10 years
Circumcision	1	10 years
Imperforate anus	1	24 hours

TABLE II
PAEDIATRIC SURGERY BY EPIDURAL BLOCK, 1956 TO 1962
INCLUSIVE

	No	Complications
Pyloromyotomies	54	1 pneumonia, 1 died
Evisceration	1	
Hemihepatectomy	1	
Volvulus	4	
Close ileostomy	1	
Duodenal atresias	3	
Agenesis terminal ileum	1	
Omphalocele (2 ruptured)		
Primary closure	4	1 died 5 days p o
Intestinal obstruct	1	
Repair with mesh	1	
Abdominal perineal resections		
Hirschsprung's	4	1 bronchitis
Redone	1	
Imperforate anus	1	
Pelvic tumour	1	Died 18 hours p o
Bil pyelostomies	1	
Hernias		
Inguinal	1	
Diaphragmatic	2	Both died p o
Intussusceptions	10	
	92	

epidural anaesthesia Since then halothane has become an important agent so that Table II shows a more conservative use of epidurals Table III depicts the anaesthetic techniques used in pyloromyotomies The preponderance of epidurals seen here occurs throughout all abdominal surgery with the exception of hernia repairs The decrease in the number of pyloromyotomies done is due to the fact that such patients are now admitted also to two other hospitals in the city of Hamilton Table IV shows the local anaesthetics used in pyloromyotomies

TABLE III
PYLOROMYOTOMIES AT HAMILTON GENERAL HOSPITAL,
1956 TO 1962 (1953 to 1955 inclusive 1 spinal, 8
general, 26 epidural)

Year	General	Epidural
1956	4	11
1957	0	15
1958	0	6
1959	0	9
1960	0	5
1961	2	6
1962	1	2
	7	54

TABLE IV
PYLOROMYOTOMIES, 1956 TO 1962 INCLUSIVE

Drug	No	Supplement	No
Xylocaine 2% with	1	N ₂ O	5
Xylocaine 1.5% 1/200,000	22	Pentothal	1
Xylocaine 1% epinephrine	20	Cyclo	4
		N ₂ O and cyclo	3
		N ₂ O and fluothane	5
Nesacaine 2%	5	N ₂ O	2
Carbocaine 1%	6	N ₂ O	2
	54		22

Xylocaine with 1/200,000 epinephrine has been the most popular but I now have a preference for Carbocaine and Nesacaine because they can be used without epinephrine Nesacaine is indicated when the Ramstedt procedure is done by a fast surgeon, for the anaesthetic time is only thirty-five minutes Carbocaine 1 per cent, or Xylocaine 1.5 per cent with epinephrine can be depended on for two hours These anaesthetics have been administered by eight of the eleven members of our staff, which explains the diversity of supplement My own preference is nitrous oxide with a loose fitting mask or a mask fitted with a Ruben's Valve, and supplement is resorted to only if the infant cries when the pyloric tumour is brought up into the incision, for any excessive respiratory movement will increase the difficulty of the myotomy This provides analgesia but does not suppress the glottic reflex Table V represents those patients handled by continuous epidural block and were done by me The children with intus-

susception were given a small amount of thiopentone as a hypnotic while the epidural was being injected. They could have been managed by a single-dose method.

TABLE V
CONTINUOUS EPIDURALS, 1959 TO 1962

Operation	Age	Anaes time	Combined
Intussusceptions	8 months	1 hour	Pentothal 2 c c
	5 "	1 $\frac{1}{4}$ "	Pentothal 2 c c
	9 "	1 "	Pentothal 3 c c
Hemihepatectomy	9 "	6 hours	Orotacheal N ₂ O and fluothane 0 25%
Omphalocele repair	2 years	3 $\frac{1}{4}$ "	
Abd perineal resect	1 "	3 $\frac{1}{2}$ "	
Hirschsprung's	1 $\frac{1}{2}$ "	3 $\frac{1}{2}$ "	
Redone	1 $\frac{1}{2}$ "	2 $\frac{1}{2}$ "	
	11 months	3 $\frac{1}{2}$ "	
	14 "	3 "	
Pelvic tumour	5 "	3 $\frac{1}{2}$ "	

The hemihepatectomy (Figure 1) consisted of mobilizing the hepatic flexure of the colon and exploration of the right perirenal area because of adhesions, but when it was found that the malignant teratoma was confined to the liver, the abdominal incision was extended through the chest to the right eighth intercostal space. The diaphragm was cut for access to the vena cava to check bleeding. Respirations were controlled to prevent paradoxical breathing. The right hepatic lobe and a large wedge of the left lobe were removed while the vena cava and the portal vein were clamped for five minutes. Succinylcholine was given intermittently to paralyse the diaphragm during its repair. Postoperatively the child developed jaundice and seemed to be on the verge of a hepatic crisis but this did not occur.

The infant with omphalocele (Figs 2, 3, and 4) had the primary repair done under a single dose and the secondary with a combined continuous epidural. This repair was complicated by the presence of the liver and a mass of gut in the omphalocele and a large defect in the abdominal wall, which was closed by Mersilene mesh. The block was more difficult because of an accentuated lumbar curve. The procedure was accomplished under excellent relaxation, and most important, with constricted, tapelike bowel, and spontaneous respirations.

The abdominal perineal resections for Hirschsprung's disease are of some interest. One patient had chronic bronchitis from birth and the operation was cancelled several times because of chest infection. After operation the chest was a problem. Another resection (Fig 5) was a difficult operation because the pathologist was unable to find any normal ganglionic tissue until sections were taken from well up the colon, which resulted in a rather stretched bowel, with precarious blood supply, for it was anchored by the colostomy. The anastomosis broke down after eight days (Fig 6). The whole procedure was repeated with the additional transfer of the colostomy—a real surgical problem in a sick child! This child received a minute dose of succinylcholine to relax spasm of the diaphragm caused by accidental movement of the child's head which

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HAMILTON CIVIC HOSPITALS
ANAESTHETIC CHART

DATE 19 Sept 60 HOSPITAL HGH ☒ VHH ☐ NFH ☐
PREOPERATIVE DIAGNOSIS Malignant teratoma of liver
PROPOSED OPERATION Hepatectomy(hemi-)

John G 9 mos.

SURGEON Cameron

RECORD OF PHYSICAL EXAMINATION

DATE TIME PULSE B P 100 RESPIRATION TEMPERATURE
PHYSICAL EXAMINATION NEGATIVE EXCEPT FOR THE FOLLOWING
Chest and heart neg. Abdomen distended. Liver at umbilicus. Had biopsy done at St Joseph's - malignant teratoma of rt lobe of liver.
Hb. 9.8 G Wt. 18 lbs 9 oz.

PRE OPERATIVE SEDATIVE Atrop. gr 1/200 RISK A B C D EMERGENCY

ANAESTHETIC AGENTS & TECHNIQUES

REMARKS

1	Combined Epidural (continuous) and orotracheal N ₂ O and Fluothane	
2	Nesacaine 3 % 8 ccs 8.15 am.	Nesacaine 2 % 5 ccs. 11.40 am.
3	" 2 % 2 " 8.20 am	" 2 % 5 " 12.10 pm.
4	" 2 % 5 " 9.00 am.	1500 blood during operation.
5	" 2 % 5 " 9.50 am	10 ccs. Ca Gluconate

OPERATION PERFORMED Rt. & wedge of lt removed.
TOTAL OPERATING TIME 8.45 - 2.10 DURATION OF ANAESTHETIC 8.00 - 2.15
CONDITION ON LEAVING OPERATING ROOM fair

SIGNED

F. G. Ruston, MD
ANAESTHETIST

FIGURE 1

caused it to buck on the endotracheal tube, but abdominal relaxation remained excellent to the end of operation

The last case of this group had a tumour obstructing the pelvic cavity. It was freed from above by an extraperitoneal abdominal incision, but because of the size and adherence to the sacrum, a portion of the sacrum was resected

FIGURE 2 Severe omphalocele containing liver in newborn infant

FIGURE 3 Same patient ready for second stage repair—epidural catheter in place. In this case intubation followed epidural block

FIGURE 4 The New Look following repair with Mersilene mesh

to obtain room to deliver the mass. Bleeding was excessive but blood volume was maintained by transfusion. The patient died suddenly eighteen hours post-operatively. Autopsy showed a fairly large collection of blood in spite of continuous wound suction; there was also a terminal aspiration. The pathologist gave some comfort for the tumour was a malignant neuroblastoma.

All the operations of this group were done with electrocautery dissection to cut down on incisional bleeding.

COMPLICATIONS

In addition to those already mentioned there were the following complications. One infant developed pneumonia after five days following a Ramstedt procedure but the paediatrician thought it to be from a cross infection. A newborn infant who had projectile vomiting and who showed the typical picture of pyloric stenosis after the ingestion of Lipiodol was found to have only mild pyloric hypertrophy but a myotomy was done. The infant died twelve days

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HAMILTON CIVIC HOSPITALS ANAESTHETIC CHART

DATE 7 Aug. 62 HOSPITAL

HGH	☒
MHH	☐
NFH	☐

P. S. 1½ yrs.

PREOPERATIVE DIAGNOSIS Hirschsprung's Dis.

PROPOSED OPERATION Abdominal
perineal pull through.

SURGEON G. Cameron

RECORD OF PHYSICAL EXAMINATION

DATE TIME PULSE BP 120 RESPIRATION TEMPERATURE
PHYSICAL EXAMINATION NEGATIVE EXCEPT FOR THE FOLLOWING Chest and heart neg.
Admitted two times but operation cancelled because of respiratory
infections. Transverse colostomy at 1 week. Weight 24 lbs.

PRE OPERATIVE SEDATIVE Atrop. gr. 1/300

RISK A B C D EMERGENCY

ANAESTHETIC AGENTS & TECHNIQUES

REMARKS

- 1 Combined continuous epidural
- 2 5 ccs 2½ % Pentothal + ½ cc. Anectine + orotracheal N₂O + 0.25 %
- 3 Fluothane with # 4 Portex tube and Leigh - Slater Valve.
- 4
- 5 Epidural initial dose Carbocaine 1.5 % 10 ccs. at 8.20 am.

OPERATION PERFORMED

TOTAL OPERATING TIME 3½ hrs. DURATION OF ANAESTHETIC 4 hrs.
CONDITION ON LEAVING OPERATING ROOM satisfactory

SIGNED

ANAESTHETIST

FIGURE 5

later and autopsy established that death resulted from congenital bilateral hydronephrosis and hydroureters and a monilial pneumonitis, the latter thought to have arisen from "either vaginitis of the mother or antibiotic therapy given the infant"

There was another death in a neonate in which epidural anaesthesia was a contributing if not a precipitating factor. The diagnosis was intestinal obstruction in a moribund infant who died immediately after the block had been given before surgery was attempted and on who no autopsy was done.

Another complication which does not appear in the list of operations applies to the continuous technique. A secondary repair was scheduled in an infant with a severe omphalocele which had ruptured before birth. I had promised to demonstrate the continuous epidural technique. This patient had the same lumbar deformity which was observed in the case mentioned earlier. The infant was intubated and carried on nitrous oxide and the needle was inserted without difficulty into the epidural space but when the catheter was advanced it met

FIGURE 7 Autopsy dissection showing epidural haematoma

an obstruction. I used more force than I should have done and suddenly there was no resistance but blood came back in the tubing. The block was abandoned and the repair was completed under a relaxant and halothane with controlled and assisted respirations. This repair was difficult for although muscular relaxation was adequate the wound was filled with dilated loops of bowel and bleeding was rather marked. Cardiac arrest occurred suddenly as the dressing was being applied even though spontaneous respirations had seemed adequate.

The orotracheal tube was still in place and resuscitation measures were carried out immediately, and the heart started with external massage, but it finally stopped even though the mesh was cut vertically to relieve abdominal tension. The child died from respiratory and circulatory embarrassment secondary to increased intra-abdominal pressure from too tight a repair. Figure 7 is the photograph of the autopsy dissection of the site of the epidural. This is what the pathologist said "On opening the vertebral arches there was an epidural haematoma found in the lumbar region 4.5 cm in size. There was no subdural haematoma. There was a congested liver and hyperaemia and oedema of the lungs, with partial atelectasis (especially in the lower lobes, bilaterally)." The complication of extradural haematoma is mentioned by Bromage where stilettes have been used to stiffen catheters.³

There has been no total spinal anaesthesia in this series unless for the patient with intestinal obstruction who died. However, in a previous report² this occurred in two cases, but this was before suitable needles were available. The hazard of inadvertent total spinal anaesthesia has been overemphasized in the literature.^{6,7} It is an unnerving experience but should not cause alarm if it is recognized, and if equipment is ready to cope with it as it should be. In the two cases mentioned, both infants were apnoeic for fifteen minutes, then tracheal tugging appeared, and finally full respirations returned in forty-five minutes, during this time oxygen was administered by mask.

A complication which I wish to emphasize is from the same report² "One infant nearly died from asphyxia while the block was being done when its head became flexed on the chest causing complete mechanical obstruction."

No convulsions were encountered in this series, moreover, those reported in the previous paper were due to overhydration or toxic absorption from reduced strangulated bowel in gravely ill infants.

DISCUSSION

The opponents of paediatric epidural anaesthesia usually write from a wealth of experience in general anaesthesia, but with little or no familiarity with conduction anaesthetic techniques. Statements are made, quoted, and requoted in the literature until they become "Gospel Truths." I do hope that my observations are tempered by a certain amount of skill in most anaesthetic procedures. Furthermore, my observations have been confirmed by other anaesthetists who are proficient in epidural anaesthesia for infants and children, by our paediatricians, and by our surgeons. Moreover, although the Children's Wing of the Hamilton General Hospital no longer attracts the admissions it formerly did because newer and finer facilities are available, yet paediatric epidural anaesthesia is being used increasingly in the other hospitals in the city. Why, then, are we in this non-conformist position?

The anaesthetist is faced with the problem of providing relaxation and good exposure for abdominal surgery. These conditions should not be obtained at the risk of the general well-being of the patient, who requires a minimum of

systemic change and a quick return to homeostasis. Segmental conduction anaesthesia, alone or in combination with light general anaesthesia, has seemed to fulfil the requirements. It has been stated that "with adequate anaesthesia and relaxation by any method, the muscles of respiration are inevitably affected and weakened"⁴ I do not believe this applies to epidural analgesia, for the primary innervation of the diaphragm by the phrenics should not be involved. Clement A. Smith says "Breathing is essentially diaphragmatic and abdominal in neonatal life, the thorax offering little more than a relatively fixed chamber into which the descent of the diaphragm induces the movement of air"⁸ Another important fact can be inferred since respirations are spontaneous, carbon dioxide levels are automatically controlled by the patient's breathing of air or a light anaesthetic mixture by a non-rebreathing valve. This also explains why bleeding is frequently decreased.

Prematures, neonates, and infants up to two weeks of age have shown varying degrees of atelectasis or faulty expansion. In 1942 I was impressed by the work of Coryllos and Birnbaum on the aetiology of atelectasis.⁹ They remarked on the rapidity with which oxygen and anaesthetic gases are absorbed from the lung distal to a bronchial obstruction, and the role of the nitrogen of the air in preventing this. Because of this it seemed a good idea to adapt epidural block to infants. General anaesthetics decrease respiratory efficiency except where respirators or faithful manual compression of the bag is practised. The first has been impractical, and high flows of gases place the infant in an atmosphere which is highly absorbable so that the stage is set for increased atelectasis if it is already present, or for its development if the bronchial tree is obstructed by secretions. With epidural block the patient can breathe air, or a mixture of air, gas, and oxygen, and still be protected by the "mechanical buffer, nitrogen."

Recent investigations into the circulatory system of the infant have emphasized "central pooling," "increased peripheral resistance," etc. I shall not go into this but shall simply say that the infant differs markedly from the adult. There is, however, a similarity too, for some infants show extremely high systolic pressures. It is true that I did not report blood pressures in my early cases, because the readings were unreliable. Since smaller cuffs have become available, blood pressures have been recorded. I believe that halothane has stimulated the interest in blood pressures, for no other anaesthetic agent or technique has such an unpredictable effect on the circulatory system. The charts shown in Figures 8 and 9 are submitted to show that we are interested in blood pressures as a means of supervising the administration of an anaesthetic, but it must be remembered that a blood pressure record is only one of several means of following the patient's response to anaesthesia and surgery. Colour, pulse, heart and breath sounds are all very reliable signs. These charts also point out the difference between the circulatory reaction of the infant and that of the adult, for the infant does not show the characteristic falls of blood pressure that are observed in adults following a spinal or epidural block involving the splanchnic outflow.

I am sure all are agreed that any decrease in the circulating volume or a

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HAMILTON CIVIC HOSPITALS ANAESTHETIC CHART

P. L. 6 weeks.

DATE 21 Oct 56 HOSPITAL N F H ☒ ☐ ☐
 PREOPERATIVE DIAGNOSIS Pyloric stenosis
 PROPOSED OPERATION Pyloromyotomy

SURGEON Mighton

RECORD OF PHYSICAL EXAMINATION

DATE TIME PULSE B P 110 RESPIRATION TEMPERATURE
 PHYSICAL EXAMINATION NEGATIVE EXCEPT FOR THE FOLLOWING
 Chest and heart neg. History of projectile vomiting. Tumour felt.
 Nutrition and hydration good. Weight 8½ lbs.

PRE-OPERATIVE SEDATIVE Sod. Luminal gr. ¼ & RISK (A) B C D EMERGENCY

ANAESTHETIC AGENTS & TECHNIQUES Atrop. gr. 1/450 REMARKS

1

2 Epidural 6 ccs. Xylocaine 1% & 1/200,000 Epinephrine

3 Hanging drop test positive.

4

5 O₂ only

TIME POSITION SURGEON

COMMENTS

Excellent anaesthesia
and relaxation.

OPERATION PERFORMED as above

TOTAL OPERATING TIME 30 min. DURATION OF ANAESTHETIC 40 min.

CONDITION ON LEAVING OPERATING ROOM excellent

SIGNED

F. J. Ruston, M.D.
ANAESTHETIST

FIGURE 8

change in the electrolyte balance increases the anaesthetic risk by any technique
 Robert M Smith underlines this by saying

An additional claim is made that I believe is false and dangerous, that is, that regional anaesthesia is indicated in toxic patients such as those with peritonitis and dehydration

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HAMILTON CIVIC HOSPITALS ANAESTHETIC CHART

DATE 15 Oct. 58 HOSPITAL ☒ HGH ☐ VHH ☐ NFH ☐

PREOPERATIVE DIAGNOSIS Intussusception

PROPOSED OPERATION Reduction

P. F 8 months.

SURGEON Mighton

RECORD OF PHYSICAL EXAMINATION

DATE TIME PULSE B P 120 RESPIRATION TEMPERATURE

PHYSICAL EXAMINATION NEGATIVE EXCEPT FOR THE FOLLOWING

History of bloody stool. Intussusception confirmed by Barium enema and reduced by manipulation under flourescopy. However as mass remained patient was booked for laparotomy. Chest and heart neg. Wt 21 lbs.

PRE OPERATIVE SEDATIVE Sod. Luminol gr. $\frac{1}{2}$ & RISK (A B C D) EMERGENCY

ANAESTHETIC AGENTS & TECHNIQUES Atrop. gr 1/450 REMARKS

1

2 Epidural loccs. 1% Xylocaine with 1/200,000 Epinephrine

3

4 O₂ only

5

OPERATION PERFORMED Laparotomy plus appendectomy

TOTAL OPERATING TIME 40 min. DURATION OF ANAESTHETIC 50 min.

CONDITION ON LEAVING OPERATING ROOM good

SIGNED

V. J. Ruston, M.D.
ANAESTHETIST

FIGURE 9

Ruston goes so far as to say that time need not be taken to hydrate such patients prior to anesthesia I am convinced that the use of regional anesthesia in sick patients with high fever and rapid pulse is dangerous and ill advised Such patients show decreased tolerance to local as well as general anesthetics Several experiences have confirmed this belief Any patient who is acidotic or otherwise critically ill should be fully prepared before receiving either regional or general anesthesia ¹⁰

My statement, which he paraphrased, "In emergency cases such as intestinal obstruction or appendicitis with ketosis, the operation need not be delayed until fluid levels are restored,"² is no longer valid. I made it at a time when fluid and electrolyte balance was not as well regulated as today. Many patients were presented to the anaesthetist either dehydrated or overhydrated. However, the confidence in the epidural technique is expressed, perhaps too strongly, from personal observation. I cannot leave this subject without saying that I have never observed a heat convulsion under conduction analgesia but had it demonstrated under a general anaesthetic in a well-prepared three-year-old child with a perforated appendix. Moreover, I am convinced that it is foolhardy to delay operation once the diagnosis of strangulated intestinal obstruction is made, for it is an unequal race to try to catch up on fluids, and can so easily end in irreversible shock. But should such patients be subjected to a block? The recent report by Bornside and Cohn of the Department of Surgery of the Louisiana State University School of Medicine may give a clue. They found that "Peritoneal fluid from dogs with experimental strangulation intestinal obstruction was not lethal when injected into unanesthetized dogs. This peritoneal fluid was lethal for dogs anesthetized with Pentothal Sodium."¹¹

So much has been written regarding the difficulties encountered in epidural anaesthesia that some have been frightened away from its use. The most difficult block is in the adult, for the dura is so easily punctured unless a large-bore short-bevel needle or a No. 20 Wagner Point Needle is used. Next to this group are the premature and newborn infants, but here the difficulty is to identify the interspinous space because of the rubbery texture of the subcutaneous tissue. The easiest are in the older infants, e.g. pylorics, in which the subcutaneous tissue is decreased. Let me repeat, the bogey of inadvertent total spinal anaesthesia has been exaggerated. It is quite conceivable that this could result from a hasty injection or a laterally placed needle so that a lumbar nerve is pierced. This has been discussed by Mostert,⁶ who showed that injection of 5 c.c. of Lignocaine with methylene blue into a lumbar nerve of a dog one centimetre from the cord passed into the subarachnoid space within 15 seconds through the perineural spaces. He uses this to emphasize the importance of a test dose. I do not believe in the five-minute wait to see if spinal anaesthesia develops, for it is more important to get a good cushion of fluid between the dura and the needle point so that movement cannot puncture the dura. The necessity for placing the needle in the midline must be evident.

Infants have an amazing tolerance to local anaesthetic drugs. This has been observed in spinal anaesthesia, where relatively greatly increased dosage is required.¹² The same is true of epidurals, e.g., an abdominal hysterectomy in an adult requires 25 c.c., but a pyloric of 8 pounds needs 5 c.c. Also the recovery time of respiration in the infants mentioned earlier was 45 minutes, whereas that of three adults who developed inadvertent total spinal anaesthesia was well over two hours—both the infants and adults having received 2 per cent Xylocaine with epinephrine! No toxic reaction has been seen even when double the dosage was given in one case, when the first dose went into the muscle when the needle was moved. Two cases of pyloromyotomy who received double the dose in error had

some respiratory embarrassment from partial diaphragmatic paralysis but normal respirations returned before the completion of surgery. The dosage formula is only a rough guide and is elastic. An infant who has lost weight needs the full or an increased dose because of the relatively large frame, while the premature with its large head in proportion to its body requires less.

Epidural block results in profound relaxation which can only be approximated by general anaesthesia with a relaxant, which does encroach on respiratory efficiency. This is only part of the picture, for exposure and closure is more readily accomplished under a block. As Macintosh says "Motor paralysis of the splanchnic nerves is revealed by the contracted tapelike gut, and this effect is accentuated by the unopposed and unimpaired tonic action of the vagi on the muscles of the intestinal wall."¹³ The same could apply to spinal anaesthesia if it were possible to control the level of anaesthesia in an infant. I am sure this explains the statement of Leigh and Belton,¹² when they consider spinal anaesthesia, that "In infants and young children, however, the surgeon may be disappointed with the continued distention of the bowel, in spite of well relaxed muscles." Our surgeons are unanimous in the opinion that the gut is contracted under epidural anaesthesia. Moreover, it is interesting to see distention occur under continuous epidural anaesthesia if an additional dose of solution is delayed, and the return of constricted bowel within five minutes of injection.

The following are some of the ways of keeping out of trouble if you are tempted to use epidural blocks in paediatric surgery, although the cynic may say "Just don't ever even think about using such a technique."

- 1 Never attempt epidural anaesthetic in an infant before you have used the method in a larger patient and have built up some self-confidence.

- 2 Reserve epidurals for procedures requiring good relaxation in premature or newborn infants, and for those who have a history of respiratory complications or intestinal obstruction. There is also a group requiring maximal relaxation for long periods, e.g., those undergoing abdominal perineal resections for Hirschsprung's disease.

- 3 Sterile equipment and technique is essential. If kits were used more often, the vials of anaesthetic solution should be included in them, for all can be autoclaved except those containing epinephrine.

- 4 Proper positioning of the patient is important, especially in the sitting posture. The head must be supported so that the airway is not obstructed.

- 5 A proper pre-anaesthetic check must be done—this includes history, physical examination, weight, seeing that gastric suction is working (pylorics and those with intestinal obstructions have a large Levine tube in place prior to and during operation), that cut-downs are running and have been started with large enough catheters, and that resuscitation equipment is in a ready state. Absolute vigilance should be practised.

- 6 The recommended needles are excellent (Figs 10 and 11). They are the 2-inch No. 22 gauge Becton, Dickinson needles with added flanges,¹⁴ from the Special Anaesthetic List, catalogue No. 466LNRH. For the continuous method, the thin-walled No. 18 needle with the Crawford Point is suggested, for it carries the B-D vinyl tubing, size VX020, and can be autoclaved.

FIGURE 10 Epidural needle with Wagner Point modified by flanges introduced by Stringer

7 The simplest method is the best for identifying the epidural space. This is the hanging drop, but if this test is not immediately positive, rely on the loss of resistance.

8 The following applies to continuous epidural blocks. Always point the bevel cephalad and always inject some solution before passing the catheter into the needle. Be sure the inner curve of the catheter faces cephalad and advance the catheter only 2 or 3 cm beyond the needle point so that it will not run along a nerve trunk.³ *Never* withdraw or rotate the catheter while the needle is still in place—this will prevent the loss of a tip by shearing. *Never* use force to advance the catheter (see Fig 7!)

9 Extreme care must be used if the patient is placed in a head up position during and after surgery. An order is written to keep the patient flat for two hours postoperatively, which allows for the complete return of muscle tone and the disappearance of the sympathetic block.

In conclusion, let me leave the following thoughts with you. It is admitted that general anaesthesia techniques have evolved to a state of excellence but there still

FIGURE 11 Continuous epidural kit with vinyl catheter and thin-walled No 18 needle (lower left)

remain the problems attendant on intubation, carbon dioxide build-up, resistance in gas machines, toxic reactions from anaesthetic agents, and unpredictable results from relaxants. On the other hand, conduction anaesthetic techniques were introduced at a time when local anaesthetic drugs, such as cocaine and novocaine were undependable and even fraught with danger to the patient. But today these techniques are unpopular even though we have such excellent needles and superb local anaesthetic solutions. I am perplexed at the hesitation, or perhaps more correctly, disinterest that is shown towards all conduction anaesthesia for paediatric surgery. Often it is looked on as a "parlour trick." I would not have it otherwise unless the whole team of surgeon, paediatrician, and anaesthetist have confidence in the application of epidural techniques to paediatric surgery.

SUMMARY

The role of epidural anaesthesia in paediatric surgery is presented as a continuation of the preliminary reports which were published in 1954 and 1957. The

technique of epidural block has been modified by the advent of Carbocaine and Nesacaine so that Xylocaine is no longer in a singular position. The introduction of the modified Wagner Point needle has added greatly to the safety and facility of epidural block. Continuous epidural anaesthesia has been used in prolonged serious abdominal operations. A reply has been attempted to the criticism of paediatric epidural anaesthesia. Safety measures have been emphasized. The author believes that although epidural anaesthesia can hold a position in the practice of paediatric anaesthesia, yet it should not be used unless all the members of the surgical team have confidence in its application.

RÉSUMÉ

Dans deux articles antérieurs,^{1,2} nous avons parlé de l'usage de l'anesthésie épidurale en chirurgie pédiatrique. Le but du présent travail est d'abord de faire part de notre expérience dans ce domaine à l'hôpital Général de Hamilton, depuis la publication des articles mentionnés, puis de démontrer pourquoi nous croyons que cette technique possède une place bien déterminée en anesthésie pédiatrique et enfin d'essayer de dissiper quelques-uns des doutes qui ont conduit à l'énoncé suivant concernant l'anesthésie pour les pylorotomies "l'opportunité d'utiliser l'anesthésie épidurale nous laisse sceptiques"⁴

Il existe deux techniques. L'une à dose unique pour la chirurgie abdominale d'une durée inférieure à deux heures, et l'autre, à doses multiples, appelée également épidurale continue pour la chirurgie abdominale chez des malades de plus de trois mois dont l'opération doit durer plus de deux heures. A ces deux méthodes, on peut ajouter du thiopentone ou un anesthésique général (un tube orotrachéal peut être mis en place si nécessaire).

Chez les prématurés et les tout petits, on fait le blocage sans anesthésie, l'enfant étant en position assise, pendant qu'un assistant lui tient fermement les coudes et les genoux, et que la tête du malade est supportée de façon à ce que la colonne vertébrale soit légèrement fléchie. Nous suggérons une aiguille N° 22 B D Wagner Point, porteuse d'ailerons. Pour identifier l'espace épidural, nous utilisons le signe de la goutte pendante, mais si cette épreuve ne s'avère pas positive immédiatement, nous utilisons celle de la perte de résistance. La technique de l'épidurale continue ne peut être appliquée que chez les enfants de plus de trois mois, parce que nous utilisons une aiguille N° 18 à paroi mince, à travers laquelle nous passons un tube B D en vinyl (tube qui peut être stérilisé à l'autoclave) et qui mesure N° V x 020. Il faut agir avec douceur, le passage du tube peut être facilité par l'injection de 2 ou 3 ml de la solution anesthésique. Il ne faut pas retirer ou tourner le cathéter pendant que l'aiguille demeure en place. Le cathéter doit dépasser le bout de l'aiguille de deux centimètres seulement et, une fois qu'on a retiré l'aiguille avec soin, on fixe le cathéter au dos avec du diachylon et l'on adapte à l'extrémité distale du cathéter la seringue contenant la solution anesthésique, et munie d'une aiguille hypodermique.

Pour les deux techniques, le calcul de la dose se fait d'après la formule

$$\frac{1}{2} \text{ (poids en livres) plus } \frac{1}{2} \text{ ou } 1 \text{ ml} = \text{dose en ml}$$

Nous avons utilisé les substances suivantes Xylocaine 1 pour cent et 1.5 pour cent avec de l'épinéphrine 1/200 000 et de la carbocaine 1 pour cent à 1.5 pour cent, les deux mélanges assurent une anesthésie de deux heures. La Nésacaine à 2 pour cent a été suffisante pour des pylorotomies d'une durée de 35 minutes et pour donner des doses additionnelles au cours d'anesthésies épidurales continues.

Les tableaux ci-contre parlent d'eux-mêmes et font voir l'usage que nous avons fait de cette technique à l'hôpital Général de Hamilton. Le tableau I représente une copie de la feuille d'anesthésie remplie au cours d'une hémihépatectomie pour un tératômémalin. Les tableaux 2, 3 et 4 montrent le problème de la réparation secondaire d'un omphalocèle important.

Le tableau V montre l'anesthésie pratiquée pour une résection abdomino-périnéale pour une maladie de Hirschsprung, et le tableau VI détaille l'anesthésie faite pour une deuxième opération: le déplacement de la colostomie parce que l'anastomose au rectum avait cédé.

Le dernier cas d'anesthésie épidurale combinée fut pratiqué pour la résection abdomino-périnéale d'un neuroblastome. Cet enfant est mort 18 heures après l'opération d'une hémorragie méconnue et d'une aspiration terminale.

Les complications ont été peu nombreuses. Il est survenu une mort immédiatement après le blocage chez un nouveau-né moribond souffrant d'une obstruction intestinale. Nous n'avons pas eu d'autopsie, la cause de la mort n'a pas été établie mais, sans aucun doute, l'anesthésie a été une cause adjuvante. Une autre complication non mentionnée dans le tableau II a consisté en un hématome épidural (figure 7) découvert à l'autopsie, il s'agissait de réparer un omphalocèle important rupturé sous anesthésie générale avec usage de myorésolutifs parce que le blocage épidural continu a dû être abandonné à cause d'une hémorragie provoquée par la mise en place du cathéter: mise en place trop violente. La mort est survenue à la suite d'un arrêt cardiaque occasionné par des troubles respiratoires et circulatoires due à une réparation trop serrée. La complication signalée dans un article antérieur—l'asphyxie—est survenue parce que l'assistant a laissé la tête en flexion produisant ainsi une obstruction mécanique des voies respiratoires.

Nous faisons valoir les raisons qui nous ont incités, ici à Hamilton, à continuer d'employer l'épidurale en pédiatrie. L'anesthésie générale, inévitablement diminue l'efficacité respiratoire, qu'on y ajoute ou non des myorésolutifs. Au cours de l'anesthésie épidurale, cela ne devrait pas exister, car les phréniques ne sont pas touchés et, chez les nouveaux-nés, la respiration est essentiellement diaphragmatique et abdominale. De plus, sous anesthésie régionale la respiration spontanée règle le taux de gaz carbonique, ce qui explique la diminution du suintement sanguin.

Les enfants souffrant d'atélectasie pulmonaire ou de troubles de l'expansion pulmonaire peuvent respirer de l'air sous anesthésie épidurale et l'azote de l'air devient une protection contre l'expansion de l'atélectasie en empêchant les parois des alvéoles aérées de s'accoler.

Les tableaux VIII et IX répondent aux critiques contre le fait que les pressions artérielles n'ont pas été prises. De plus, chez les enfants, on observe une stabilité

des pressions artérielles, alors qu'au contraire chez les adultes, sous anesthésie rachidienne ou épidurale atteignant les segments splanchniques, on peut prédire presque à coup sûr les chutes abruptes de la tension artérielle

La critique que faisait Robert M Smith, dans un article antérieur, était justifiable, cependant, il ne faut pas oublier que, aujourd'hui, chez nos malades, l'équilibre des liquides et des électrolytes est mieux fait. Sans doute, il faut prendre le temps de rétablir cet équilibre à moins qu'il ne s'agisse d'une obstruction intestinale par étranglement où tout retard à l'opération pourrait aboutir à un état de choc irréversible.

L'anesthésie épidurale devient avantageuse chez les malades de cette catégorie. La justification de cela peut être prise dans le travail de Cohn et Bornside qui ont trouvé que si l'on injectait à des chiens de l'exsudat péritonéal d'autres chiens morts par obstruction mécanique expérimentale, ils survivaient, mais ceux qui étaient anesthésiés au thiopentone pour cette injection mouraient.

Les difficultés citées dans la littérature au sujet de l'anesthésie épidurale ont contribué à empêcher l'usage de cette méthode. On a insisté sur le blocage rachidien total, accidentel, si l'on en fait le diagnostic, il ne devrait pas constituer un problème sérieux. On peut éviter ce blocage en plaçant l'aiguille sur la ligne médiane, autrement l'aiguille peut traverser une racine nerveuse et permettre à la solution anesthésique de pénétrer dans l'espace sous-arachnoïdien par les trous périneuraux. Nous ne recommandons pas la dose d'essai et l'attente de cinq minutes, car il est préférable d'obtenir un manchon de solution entre la pointe de l'aiguille et la dure-mère. Ce qui est essentiel, ce sont la vigilance et une préparation adéquate.

La tolérance des enfants pour les anesthésiques locaux est étonnante. Nous n'avons pas observé d'effets toxiques avec des doses doubles de la normale. Il est survenu accidentellement chez deux enfants des anesthésies rachidiennes totales (depuis le rapport préliminaire), elles ont entraîné de l'apnée suivie, au bout de 15 minutes, par de la traction inspiratoire du maxillaire inférieur et, après 45 minutes, d'un retour complet de la respiration. Trois adultes, chez qui la chose est survenue, sont demeurés en apnée durant plus de deux heures.

Sous bloc épidural, la chirurgie est plus facile car le relâchement abdominal est complet, mais ce qui est plus important, c'est que l'intestin est comme un ruban et en constriction à cause du blocage de l'innervation sympathique, ce qui lève le frein de l'action parasympathique sur l'intestin (à la condition que le blocage s'étende aux segments splanchniques).

Nous avons fait neuf recommandations pour augmenter la sécurité des techniques épidurales en chirurgie pédiatrique. Finalement, les problèmes se rattachant à l'anesthésie générale sont mentionnés afin de chercher à savoir pourquoi l'anesthésie par conduction est-elle négligée à ce point en anesthésie pédiatrique, alors que nous avons à notre disposition de si belles aiguilles et de si bonnes solutions anesthésiques. En dépit de tout cela, je n'agis pas autrement, pourvu que toute l'équipe constituée du chirurgien, du pédiatre et de l'anesthésiste ait confiance à l'indication de l'anesthésie épidurale pour la chirurgie de l'enfant et du nouveau-né.

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