A desire to be free from pain is an innate part of human nature. Though the labor and delivery process can be one of the most fulfilling and self-realizing encounters of womanhood, for some it can be a most painful and unpleasant experience. Even if the parturient has received psychoprophylaxis training (Lamaze method), approximately one-third to two-thirds of the mothers will request additional pain reduction.¹ There has been increasing demand for the specialized skills of anesthetists to lessen the pain of parturition.

There has been continued refinement in the use of epidural catheters for obstetrics since Aburel² first used them in 1931. Today, standard epidural technique calls for giving bolus injections of local anesthetics through a catheter in the epidural space to establish analgesia. When the level of analgesia regresses, repetitive “top-up” bolus injections are required to reestablish analgesia. Some listed disadvantages of the bolus technique include: (1) seizures if an unintentional intravascular injection occurs; (2) total spinal anesthesia for bolus intrathecal placement of the local anesthetic; (3) unstable analgesia levels as the block regresses; (4) greater fluctuations of blood pressure as the sympathectomy level rises and falls; (5) increased variability in maternal and fetal drug levels as bolus rejections are made;³ and (6) the necessity of bedside attendance for 15-20 minutes for blood pressure measurements after each “top-up” dose.

The purpose of this article is to review a variation of this technique that utilizes a continuous, volumetric infusion pump to maintain epidural analgesia for labor while avoiding the problems associated with intermittent bolus injections. The theory and technique of epidural anesthesia and obstetrical analgesia have been extensively reviewed elsewhere.⁴⁻¹⁰

Local anesthetic agents

Current obstetrical epidural drugs include bupivacaine, lidocaine, and 2-chloroprocaine. Bupivacaine is the drug most commonly utilized. It provides more sensory than motor blockade, which allows excellent analgesia with minimal motor impairment. It is highly bound to maternal proteins, which may help limit fetal exposure. Scallon¹¹ was unable to show neurobehavioral change in neonates after epidural anesthesia using bupivacaine.

Lidocaine appears to be having an obstetrical resurgence following recent reinvestigation. Abboud et al.¹²,¹³ showed that well-conducted lidocaine epidural analgesia did not affect neonatal
neurobehavioral status. Because it may be less cardiotoxic than bupivacaine, lidocaine is preferred by some practitioners.

Despite the neurotoxicity controversy, 2-chloroprocaine has an excellent reputation in obstetrical analgesia due to its rapid onset of action, short duration, and minimal maternal and fetal blood levels. Abouleish reviewed the records of 5,745 patients who received 2-chloroprocaine and found no permanent neurologic deficits. In the same report, a prospective study was undertaken of 1,147 cases. Six patients (0.4%) showed temporary neurologic complications. Epidural bupivacaine had been injected in all six cases. Four of the six also had received 2-chloroprocaine; one also received subarachnoid lidocaine; and one eventually had general anesthesia. No neurologic deficit could be conclusively attributed to 2-chloroprocaine. Furthermore, the use of this drug may be indicated for parturients who are malignant hyperthermia susceptible.

**Infusion pumps**

The concept of continuous epidural analgesia is certainly not new. The means of regulating the flow rate into the epidural space has ranged from gravity-fed standard IV micro-drippers and the Sorenson Intraflow® capillary infusion device to a wide assortment of mechanical infusion devices that are presently available. These newer infusion pumps eliminate many of the problems associated with the other devices while maintaining an extremely accurate infusion rate.

Many of the newer pumps have built-in monitoring alarms due to advancements in solid-state circuitry. Examples of these include the Abbott Lifecare Pump®, I.M.E.D.-V.I.P.®, McGaw V.I.P.®, and IVAC Model 600®. All have been found acceptable for epidural infusions. The Harvard-type syringe infusion pump, though not equipped with as many sensing devices, has proven effective in the author’s experience. One of its advantages is that no special cassette or infusion lines are required. All of these infusion devices, however, are able to deliver a regulated amount of anesthetic solution with safety.

**Infusion techniques**

After pre-hydration and insertion of the epidural catheter, the local anesthetic solution is selected (Table I). A loading dose is given if no adverse effects are encountered after the test doses. The total loading dose is 8-10 ml. When adequate maternal analgesia has been established, the epidural catheter is connected to the continuous infusion pump. The initial infusion rate is determined by the drug selected. These settings are guidelines, and each parturient must be individually evaluated. The infusion rate is adjusted to maintain adequate analgesia. On occasion there may be a need to administer a “mini-top-up” dose of 2-4 ml of the loading strength anesthetic if the analgesic level has been allowed to become inadequate. This will reestablish comfort while the infusion rate is increased to an analgesic steady state.

All solutions should be prepared using preservative-free intravenous normal saline as the diluent. Strict aseptic technique is followed, and a micro-pore filter can be installed in the infusion line. If the Harvard-type syringe pump is used, the 50-60 cc syringe is changed for every refill to prevent using a syringe whose inner barrel has been contaminated by the exposed plunger as it moves inward.

To decrease iatrogenic errors, certain safety precautions should be instituted. The nursing staff of the labor floor must be aware of the purpose of the infusion so that any problems will be promptly reported to the anesthesia staff. Proper labeling of the system is mandatory. If injection ports are in the line, they should be taped over to prevent unintentional injection of inappropriate medications. After the initial demonstration of stability, vital signs should be monitored at regular intervals. At the same time, a quick dermatome check can be made, recorded, and the infusion rate adjusted if necessary. These few guidelines promote safety.

**Table I**

<table>
<thead>
<tr>
<th>Local anesthetic</th>
<th>Loading dose strength</th>
<th>Infusion dose strength</th>
<th>Infusion rate ml/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bupivacaine</td>
<td>0.25%</td>
<td>0.125%</td>
<td>12-14</td>
</tr>
<tr>
<td>Lidocaine</td>
<td>1.5%</td>
<td>0.75%</td>
<td>14-16</td>
</tr>
<tr>
<td>Chloroprocaine</td>
<td>2.0%</td>
<td>0.75%</td>
<td>27-30</td>
</tr>
</tbody>
</table>
Discussion
Continuous infusion lumbar epidural analgesia has been found effective for maternal analgesia during labor.\textsuperscript{3,20,23-27} The most often cited benefits are directed toward eliminating seizures from intravenous injection, preventing rapid total spinal anesthesia, providing continuous analgesia, obtaining stable vital signs, and minimizing erratic maternal and fetal local anesthetic drug levels. Although not formally studied, a time saving factor appears to be another benefit.\textsuperscript{3,26,27} For the infrequent obstetrical anesthetist, this technique seems ideally suited, as the patient is usually a primigravida having a protracted, painful labor. For the busy obstetrical department, this technique efficiently utilizes personnel.

Studies of maternal and neonatal blood levels of patients receiving local anesthetics have found blood levels equal to or lower than those of parturients receiving analgesia via the bolus technique.\textsuperscript{20,23,24,27} Neonatal scores and acid-base status appear to be equal between the three types of local anesthetics.\textsuperscript{25} More operative deliveries have been associated with bupivacaine because of prolongation of the second stage.\textsuperscript{23}

No clinically significant difference in effects on the baseline fetal heart rate or uterine activity was found between the two different techniques of analgesia, nor between the types of local anesthetics used when compared to a control group.\textsuperscript{23,28}

Bupivacaine has also been associated with a higher incidence of transitory abnormal fetal heart rate patterns\textsuperscript{25,28} during both continuous infusion and intermittent bolus techniques. However, the fetal outcomes were good when measured by Apgar scores, cord acid-base status, and neurologic and adaptive capacity scores.

Stable parturient blood pressure was often noted. Maternal hypotension, if found, occurred during the loading dose. Rarely did it occur during the continuous infusion.\textsuperscript{3,20,23,27} This is especially important when administering epidural analgesia for the preeclamptic patient.

A consistent finding was the lack of tachyphyllaxis during the infusions.\textsuperscript{3,24,27} When continuous infusion bupivacaine has been used for prolonged non-obstetrical pain relief, tachyphyllaxis either did not occur or was delayed.\textsuperscript{22,29}

Weak concentrations of local anesthetics provide good analgesia while minimizing motor blockade.\textsuperscript{20,26} With bupivacaine, there is a correlation between the number of dermatomes blocked and loss of motor strength. The greater the number of dermatomes blocked, the greater the motor weakness.\textsuperscript{25} Therefore, by using weak concentra-

tions of local anesthetics and providing analgesia to the T10 level motor, motor block is minimized.

If the maternal ability to push remains effective, the infusion can continue until the time of expulsion of the fetus.\textsuperscript{24} This allows a painfree delivery, episiotomy, and, if indicated, forceps delivery.

Complications
After an epidural catheter is inserted, complications may occur if the catheter tip should migrate into a vein or the subdural space. The continuous infusion technique minimizes adverse effects. If vein migration occurs, a seizure is unlikely because the infusion rate is slow and dilute local anesthetic is being delivered. Instead, the first sign is apt to be dissipation of the block. With subdural migration, spinal block should occur slowly, allowing for prompt recognition and treatment. Both of these events are rare. Other infrequent complications associated with all forms of epidural anesthesia have been discussed by other authors.\textsuperscript{4,30}

As with all laboring patients receiving epidural analgesia (and even those who do not), attention must be given to bladder distention. Frequent palpation of the bladder and intermittent or continuous bladder drainage may be necessary to prevent the more serious sequelae of overdistention and bladder atony.

Summary
A simple, safe, and very effective method of delivering analgesia for labor via continuous epidural infusion has been presented here. The main advantages of this method are: (1) it allows delivery of constant analgesia during the course of parturition; (2) it is associated with more stable vital signs; (3) it is an alternative to bolus injections which can result in convulsions or rapid development of total spinal anesthesia; (4) it lowers or decreases the variability of local anesthetics in maternal and fetal blood; and (5) it utilizes time more efficiently. Continuous volumetric epidural infusions deliver good maternal analgesia without detrimental effects on parturition and neonatal status. This technique promotes safe, effective anesthetic care of the laboring parturient.

REFERENCES

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The opinions expressed are the author's own and do not reflect the opinions of the U.S. Department of Defense, U.S. Navy, or the Naval Hospital, Portsmouth, Virginia.