Anesthesiology, V 92, No 3, Mar 2000

ECONOMICS

Anesthesiology 2000; 92:841–50
© 2000 American Society of Anesthesiologists, Inc.
Lippincott Williams & Wilkins, Inc.

Analgesia for Labor Pain

A Cost Model

Alex Macario, M.D., M.B.A.,* W. Craig Scibetta, M.D.,† John Navarro, M.D.,‡ Ed Riley, M.D.§

Background: Epidural analgesia and intravenous analgesia with opioids are two techniques for the relief of labor pain. The goal of this study was to develop a cost-identification model to quantify the costs (from society’s perspective) of epidural analgesia compared with intravenous analgesia for labor pain. Because there is no valid method to assign a dollar value to differing levels of analgesia, the cost of each technique can be compared with the analgesic benefit (patient pain scores) of each technique.

Methods: The authors created a cost model for epidural and intravenous analgesia by reviewing the literature to determine the rates of associated clinical outcomes (benefit of each technique to produce analgesia) and complications (e.g., postdural puncture headache). The authors then analyzed data from their institution’s cost-accounting system to determine the hospital cost for parturients admitted for delivery, estimated the cost of each complication, and performed a sensitivity analysis to evaluate the cost impact of changing key variables. A secondary analysis was performed assuming that the cost of nursing was fixed (did not change depending on the number of nursing interventions).

Results: If the cesarean section rate equals 20% for both intravenous and epidural analgesia, the additional expected cost per patient to society of epidural analgesia of labor pain ranges from $259 (assuming nursing costs in the labor and delivery suite do not vary with the number of nursing interventions) to $338 (assuming nursing costs do increase as the number of interventions increases) relative to the expected cost of intravenous analgesia for labor pain. This cost difference results from increased professional costs and complication costs associated with epidural analgesia.

Conclusions: Epidural analgesia is more costly than intravenous analgesia. How the cost of the anesthesiologist and nursing care is calculated affects how much more costly epidural analgesia is relative to intravenous analgesia. Published studies have determined that epidural analgesia provides relief of labor pain superior to intravenous analgesia, quantified in one study as 40 mm better on a 100-mm scale during the first stage of labor and 29 mm better during the second stage of labor. Patients, physicians, and society need to weigh the value of improved pain relief from epidural analgesia versus the increased cost of epidural analgesia. (Key words: Cost analysis; epidural analgesia; health economics; obstetric anesthesia.)

EPIDURAL analgesia and intravenous analgesia with opioids are two techniques for the relief of labor pain.1–3 A recent metaanalysis found that women receiving epidural analgesia had lower pain scores during the first and second stages of labor than women receiving intravenous analgesia.4 In addition, each analgesic technique is associated with different complications. Recently, epidural analgesia for labor pain has come under scrutiny because of reports linking epidural analgesia with an increased incidence of cesarean section.5–7 Introduction of a new state health plan in Tennessee has been associated with a decrease in the rate of epidural analgesia among the covered population.8 This may be because of the common perception that epidural analgesia is more costly to deliver (e.g., anesthesiologist’s professional costs) or has a greater incidence of complications (e.g., cesarean section). However, intravenous analgesia might be more costly if, for example, cost and complications of intravenous analgesia were greater than expected (e.g., if physician care was required to treat maternal or neonatal respiratory depression). A precise cost analysis of epidural versus intravenous analgesia for relief of labor pain

This article is accompanied by an Editorial View. Please see: Chestnut DH: How do we measure (the cost of) pain relief? ANESTHESIOLOGY 2000; 92:643–5.

* Assistant Professor, Departments of Anesthesia and Health Research and Policy.
† Clinical Assistant Professor, Department of Anesthesia.
‡ Fellow, Management of Perioperative Services, Department of Anesthesia.
§ Assistant Professor, Department of Anesthesia.

Received from the Departments of Anesthesia and Health Research and Policy, Stanford University, Stanford, California. Submitted for publication October 14, 1998. Accepted for publication June 3, 1999. Support was provided solely from departmental and/or institutional sources. Presented as an abstract at the annual meeting of the American Society of Anesthesiologists, Orlando, Florida, October 19, 1998.

Address reprint requests to Dr. Macario: Department of Anesthesia (H3580), Stanford University Medical Center, Stanford, California 94305-5640. Address electronic mail to: amaca@leland.stanford.edu

Anesthesiology, V 92, No 3, Mar 2000
has not been published. Even if epidural analgesia is more costly, it is unknown how much more costly per patient it is for society to offer epidural analgesia. Our study aims to determine this dollar amount and provide a cost model with which to address the economics of epidural analgesia.

Costs, outcomes, and benefits can be analyzed from different points of view: the patient’s, the provider’s, the payer’s, or society’s as a whole. For example, the cost of a medical service to the payer (insurance company) equals the percentage of charges actually paid by the payer and may vary from institution to institution based on specific contracts. On the other hand, if a cost analysis takes the point of view of a patient, the relevant cost to the patient is the amount the patient pays for the service (the out-of-pocket expense not covered by insurance) plus other costs (e.g., inability to work) incurred because of illness or treatment. The cost of a medical service from society’s point of view is the total net cost to all the different components of society. A recent consensus study on economic analyses in healthcare recommended that costs be assessed from a societal perspective.9

The goal of this study was to quantify the costs (from society’s perspective) of epidural analgesia compared with intravenous analgesia for labor pain. We developed a cost-identification model to analyze the costs of providing epidural analgesia compared with the cost of providing intravenous analgesia for healthy parturients during labor. Because there is no valid method to assign a dollar value to differing levels of analgesia, the cost of each technique can be compared with the analgesic benefit (patient pain scores) of each technique.

Methods

The study was approved by Stanford University’s Human Subjects Committee. To evaluate the cost of epidural analgesia for labor pain relative to intravenous analgesia, we1 reviewed the literature to determine the rates of associated clinical outcomes and complications (e.g., postdural puncture headache).2 obtained the hospital cost for parturients admitted for delivery and the incremental hospital cost of each complication using data from the cost accounting system of Stanford University Medical Center.3 created a cost model for epidural and intravenous analgesia, and4 performed a sensitivity analysis to evaluate the cost impact of changing key variables (e.g., the rate of cesarean section associated with epidural analgesia).

Literature Review

We identified and then estimated the incidence of all complications related to each analgesic technique by examining data from multiple published studies in the peer-reviewed literature. We identified all articles on techniques for relief of labor pain by a computerized search of literature from 1976 through 1997. The following terms were used: anesthetic techniques, epidural, opioids, pregnancy, labor epidural, patient-controlled analgesia, cesarean delivery, complications, and regional anesthesia. We supplemented the search with a review of references from the retrieved articles. The lead author read all articles, correspondence, and reviews. Obstetric complications unrelated to choice of technique for pain management (e.g., postpartum hemorrhage) were not included in the cost model.

Cost of Parturients Receiving Intravenous Analgesia

To compute the baseline hospital cost for a healthy woman to deliver a baby, we began by measuring the cost of hospital care to parturients receiving intravenous analgesia for labor pain who had either a vaginal delivery or a cesarean section. We used data from actual obstetric patients cared for at Stanford University Medical Center between October 1, 1997, and February 1, 1998. We used Diagnostic Related Group 371 (cesarean section without complications) and Diagnostic Related Group 373 (vaginal delivery without complications) to identify the two groups of patients.

Once the baseline hospital cost for a parturient receiving intravenous analgesia was established, we added estimated costs arising from incremental care specific to epidural analgesia to calculate the expected cost of providing care to a hypothetical patient having epidural analgesia with a mixture of local anesthetic and opioid. We did not use actual hospital costs from parturients who received epidural analgesia, to avoid selection bias (i.e., women who select epidural analgesia for labor may have different labor patterns than women who do not receive epidural analgesia).

Cost Data

To determine total hospital costs, we examined actual hospital costs instead of patient charges, because charges are an inaccurate measure of hospital resource use. The costs to society of delivering hospital care were defined as what it costs the hospital to deliver the care (not the charges that appear on the patient’s hospital bill). Cost data were extracted from the hospital’s exist-
COST OF EPIDURAL ANALGESIA FOR LABOR

Physician professional costs related to anesthesia were included in our analysis. We assumed no incremental cost resulting from physician service for management of the intravenous analgesia. Cost of an anesthesiologist’s care for placement and management of epidural analgesia was computed using American Society of Anesthesiologists relative value system units, reimbursed at Medicare rates for our institution. The cost of an anesthesiologist’s time from society’s point of view is the cost or the result of society having given up the opportunity to use those resources for some other purpose (in this case, the resource is the anesthesiologist’s time and expertise in placing the epidural catheter and managing the epidural analgesia). As such, even though Medicare does not often pay for obstetric services, Medicare rates are a useful estimate of the professional cost of the services of an anesthesiologist. Using Medicare rates to estimate the cost of physician services is a common method in health economics research. We excluded the professional cost of the obstetrician in the analysis, because we assumed this professional cost would be unchanged whether the patient received epidural or intravenous analgesia.

The purchase (“sunk”) costs of the pumps to deliver epidural analgesia were excluded. The drug-acquisition cost for intravenous analgesics (i.e., fentanyl) was considered equal to drug costs of local anesthetic and opioid for the epidural analgesia. Complications were included in the economic model if they required treatment (use of healthcare resources).

For our primary analysis, we assumed that changes in the intensity of nursing care in the labor and delivery suite (as might be required to treat hypotension) are reflected in nursing personnel costs ($40 per hour) and in the cost estimates for clinical complications. This is traditionally the method used in health economics, because this implies that from society’s perspective a nurse’s time and expertise spent managing epidural analgesia, or complications thereof, are resources that were given up. Under this assumption, even if a nurse is salaried, there still is a cost to society to having the nurse provide incremental patient care. We only included the cost of incremental nursing care related to pain management, which was assigned an incremental cost. In other words, events requiring resources unrelated to pain management (i.e., completing the admission paperwork) and events that were identical for both types of analgesia (i.e., placement of the intravenous catheter) were not included in the cost analysis.

A secondary analysis was performed to reflect that incremental nursing care may not be an additional cost to society. In this model, the cost of nursing time equaled 0.

Societal and Patient Costs of Complications
Neonatal effects, and thus costs related to the neonate, of each choice of analgesic technique for labor pain were limited to the treatment of respiratory depression of the newborn resulting from administration of opioids to the mother. Although our economic model focused on direct medical costs, nonmedical costs were included for permanent neurologic deficits in the mother. These estimates of maternal nonmedical costs were based on loss of wages resulting from disability from the neurologic deficit. We did not include litigation costs or nonmedical costs (e.g., lost wages) in the postpartum period from differences in maternal recovery that might be directly attributable to whether a patient received epidural or intravenous analgesia.

Benefits of Epidural Analgesia
The benefit of each technique to produce analgesia was obtained from a literature review. Valid techniques to assign monetary value to improved quality of life resulting from better analgesia do not exist. A monetary value for the benefit of the pain relief obtained from epidural analgesia was not included in the model. Rather, we estimate the expected incremental cost to society of delivering epidural analgesia to a hypothetical patient so that the reader can compare it with the improved quality of analgesia (pain scores reported by
patients) with epidural analgesia. As a result we focus on the incremental costs of one analgesic technique relative to the other to generate a cost-identification model, and not a cost–benefit model.

**Cost Model**

The cost model has three main components to evaluate the incremental cost of epidural *versus* intravenous analgesia for labor pain: a basic tree (branching) structure that reflects the two alternative clinical strategies (epidural or intravenous analgesia for labor pain), the probabilities associated with chance events (e.g., complications) given each strategy, and the clinical and economic consequences of those chance events. The overall schematic is shown in figure 1.

To structure the cost analysis, we modeled a baseline case (a parturient with a term pregnancy who receives analgesia during the active phase of labor) that incorporated the best available estimates of relevant clinical variables obtained from the literature and from our institution. In the base case, the rate of cesarean section was assumed to equal 20%\textsuperscript{11} for both intravenous analgesia and epidural analgesia for labor pain, the probabilities associated with chance events (e.g., complications) given each strategy, and the clinical and economic consequences of those chance events. The overall schematic is shown in figure 1.

Results

Hospital cost data for a total of 1,290 patients were used to compute the mean hospital costs for parturients who had intravenous analgesia for labor pain followed by vaginal delivery or cesarean section (table 1). Complications (and their estimated probabilities) specific to epidural analgesia are listed in table 2, with a range of plausible values to reflect uncertainty. Table 3 lists complications that are common to intravenous and epidural analgesia but have different incidences. Table 4 has estimated costs for the outcomes listed in tables 2 and 3. Table 5 has the expected cost per hypothetical patient for a complication.

**Table 1. Baseline Costs of Hospital Care for Parturients Receiving Intravenous Analgesia for Labor**

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Mean Hospital Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaginal delivery (DRG 373; N = 1,144)</td>
<td>$3,117 (SD 1,149)</td>
</tr>
<tr>
<td>Cesarean section (DRG 371; N = 146)</td>
<td>$5,141 (SD 3,348)</td>
</tr>
</tbody>
</table>

---

Fig. 1. Model with tree structure outlining clinical consequences of epidural analgesia and intravenous analgesia. Patients who receive epidural analgesia can have complications or not have complications, and they can have vaginal deliveries or cesarean sections.
The estimated cost of an anesthesiologist’s care of a parturient requesting labor analgesia is summarized in table 6. Using these data, the expected cost for an anesthesiologist’s care for a parturient who receives epidural analgesia is: (probability of cesarean section) × (cost of anesthesiologist for cesarean section after epidural analgesia for labor pain) + (probability of vaginal delivery) × (cost of anesthesiologist for epidural placement) = 0.2 × $340 + 0.8 × $238 = $258.40. The expected cost for an anesthesiologist’s care for a parturient who receives intravenous analgesia is: (probability of cesarean section) × (cost of anesthesiologist for cesarean section) = 0.2 × $204 = $40.80. Subtracting $40.80 from $258.40 equals $218, which is the incremental expected cost of anesthesia professional services for epidural analgesia over intravenous analgesia.

Overall Results from the Cost Model
If the rate of cesarean section equals 20% for both intravenous and epidural analgesia, the additional expected cost per patient to society of epidural analgesia for relief of labor pain is $338 greater than the expected cost of intravenous analgesia for labor pain (assuming that nursing costs increase as interventions increase). This expected cost difference per hypothetical patient results from increased professional costs ($218) and complication costs associated with epidural analgesia (table 5).

Table 2. Complications (and Their Estimated Probabilities for the Base Case) Related to Epidural Analgesia are Listed with a Range of Plausible Values to Reflect Uncertainty

<table>
<thead>
<tr>
<th>Complications</th>
<th>Baseline Incidence* (%)</th>
<th>Range of Incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postdural puncture headache</td>
<td>1.5</td>
<td>0.5–3</td>
</tr>
<tr>
<td>Spinal abscess</td>
<td>0.0002*</td>
<td>0.0001–0.0003</td>
</tr>
<tr>
<td>High spinal*</td>
<td>0.002</td>
<td>0.0016–0.02</td>
</tr>
<tr>
<td>Transient paralysis (nerve palsy, radiculopathy)*</td>
<td>0.01</td>
<td>0.0086–0.1</td>
</tr>
<tr>
<td>Spinal hematoma*</td>
<td>0.0002</td>
<td>0.0001–0.0007</td>
</tr>
<tr>
<td>Increased cesarean section rate over intravenous analgesia patients*</td>
<td>0</td>
<td>0–4</td>
</tr>
<tr>
<td>Hypotension (requiring treatment)*</td>
<td>30</td>
<td>1–40</td>
</tr>
<tr>
<td>Cardiac arrest (no permanent sequela)*</td>
<td>0.0006</td>
<td>0.0001–0.009</td>
</tr>
<tr>
<td>Permanent neurologic injury*</td>
<td>0.0002</td>
<td>0.0001–0.005</td>
</tr>
<tr>
<td>Seizure*</td>
<td>0.005</td>
<td>0.004–0.009</td>
</tr>
<tr>
<td>Failure rate (no improvement over IV analgesia patients*)</td>
<td>6.3</td>
<td>1–8</td>
</tr>
</tbody>
</table>

* Rates are reported as percentage. For example, 0.0002% equals the probability of 0.000002 or 1/500,000.

The estimated cost of an anesthesiologist’s care of a parturient requesting labor analgesia is summarized in table 6. Using these data, the expected cost for an anesthesiologist’s care for a parturient who receives epidural analgesia is: (probability of cesarean section) × (cost of anesthesiologist for cesarean section after epidural analgesia for labor pain) + (probability of vaginal delivery) × (cost of anesthesiologist for epidural placement) = 0.2 × $340 + 0.8 × $238 = $258.40. The expected cost for an anesthesiologist’s care for a parturient who receives intravenous analgesia is: (probability of cesarean section) × (cost of anesthesiologist for cesarean section) = 0.2 × $204 = $40.80. Subtracting $40.80 from $258.40 equals $218, which is the incremental expected cost of anesthesia professional services for epidural analgesia over intravenous analgesia.

Overall Results from the Cost Model
If the rate of cesarean section equals 20% for both intravenous and epidural analgesia, the additional expected cost per patient to society of epidural analgesia for relief of labor pain is $338 greater than the expected cost of intravenous analgesia for labor pain (assuming that nursing costs increase as interventions increase). This expected cost difference per hypothetical patient results from increased professional costs ($218) and complication costs associated with epidural analgesia (table 5).

Table 3. Complications Common to Intravenous and Epidural Analgesia with Their Differing Incidences

<table>
<thead>
<tr>
<th>Complications</th>
<th>Intravenous Analgesia</th>
<th>Epidural Analgesia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline Incidence (%)</td>
<td>Range of Incidence (%)</td>
</tr>
<tr>
<td>Maternal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mild respiratory depression*</td>
<td>14</td>
<td>5–50</td>
</tr>
<tr>
<td>Severe respiratory depression*</td>
<td>0.1</td>
<td>0.01–0.25</td>
</tr>
<tr>
<td>Nausea/vomiting*</td>
<td>5</td>
<td>2.5–10</td>
</tr>
<tr>
<td>Pruritus*</td>
<td>5</td>
<td>1–15</td>
</tr>
<tr>
<td>Fever*</td>
<td>6</td>
<td>3–10</td>
</tr>
<tr>
<td>Instrumental vaginal delivery*</td>
<td>10</td>
<td>5–15</td>
</tr>
<tr>
<td>Oxytocin augmentation*</td>
<td>32</td>
<td>10–80</td>
</tr>
<tr>
<td>Backache*</td>
<td>12</td>
<td>2–50</td>
</tr>
<tr>
<td>Urinary retention (catheterization)*</td>
<td>6</td>
<td>1–10</td>
</tr>
<tr>
<td>Fetal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neonatal resuscitation (respiratory depression)*</td>
<td>4.5</td>
<td>1–10</td>
</tr>
<tr>
<td>Duration of labor (h)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First stage of labor*</td>
<td>6 h†</td>
<td>5–8 h</td>
</tr>
<tr>
<td>Second stage of labor*</td>
<td>1.5 h†</td>
<td>1–2.5 h</td>
</tr>
</tbody>
</table>

* Severe respiratory depression as might occur from inadvertent high spinal is included in table 2.
† Duration of active phase of labor (cervical dilatation from 4 to 10 cm) – 1.0 cm/h.

Anesthesiology, V 92, No 3, Mar 2000
Sensitivity Analyses

If nursing costs for incremental interventions related to pain management equal 0, then the additional cost of epidural analgesia is reduced from $338 to $259. Also, if epidural analgesia results in a higher rate of cesarean section, then a 1% increase in cesarean-section rate increases the expected cost of epidural analgesia by $21 (extra hospital cost and anesthesiologist cost for cesarean delivery). The overall cost profile is “sensitive” to the cost assigned to an anesthesiologist’s care for epidural placement and management. For example, if the cost assigned to the anesthesiologist’s professional service increases by $10 per unit, then the incremental cost of the anesthesiologist increases from $218 to $346.

Discussion

Other studies have shown that women receiving epidural analgesia have lower pain scores during the first and second stages of labor than women receiving intravenous analgesia. We demonstrate the use of a micro-costing model to quantify that costs associated with professional fees and complications make epidural analgesia more costly than intravenous analgesia. Patients,
Value to Patients of Epidural Analgesia for Labor

A literature review confirms that epidural analgesia provides better pain relief than intravenous analgesia. This improvement was quantified and summarized in a metaanalysis by Halpern et al. to be 40 mm (95% confidence interval, 38–42) on a 100-mm scale during the first stage of labor and 29 mm (95% confidence interval, 21–38) during the second stage of labor. It is very difficult to measure the monetary benefit of this improved pain relief. We did not choose to do a cost-effectiveness analysis, incorporating quality-adjusted life years as the unit of outcome measured, because this approach may not apply in evaluating acute conditions such as labor pain.

Patients value labor analgesia. For example, Sharma et al. found that although 90% of women were satisfied with epidural analgesia for management of labor pain, only 65% of parturients receiving intravenous analgesia...
were satisfied. In addition, inadequate pain relief may increase the incidence of posttraumatic stress disorder. In such vulnerable patients the value of epidural analgesia may be significant. Also, we found no data documenting return-to-work statistics for women having epidural analgesia versus intravenous analgesia. It may be that improved pain relief from epidural analgesia results in accelerated maternal recovery. Health plans must balance any cost savings associated with restricting use of epidural analgesia with the consequences of patient dissatisfaction if epidural analgesia for labor is not covered.

The anesthesia-related maternal mortality rate during cesarean delivery has been measured to be approximately 32 per million for general anesthesia and 1.9 per million for regional anesthesia. This difference may result in part from the use of regional anesthesia for lower-risk elective cesarean deliveries. Reduction in the maternal morbidity rate related to an epidural catheter being in place when an emergent operative delivery is required may be important, because cesarean-section rates for fetal distress range from 2.0% to 8.7%. Thus, an additional benefit of epidural analgesia may be reduction of morbidity rate (and reduction in the rate of loss of primary child caregiver) associated with an emergent general anesthetic, because epidural anesthesia can be delivered via the preexisting epidural catheter.

Dependence of Costs for Epidural Analgesia on Method of Apportioning Cost of Anesthesiologist

The overall cost profile of epidural and intravenous analgesia is most affected by the cost assigned to an anesthesiologist’s care for epidural placement and management. A different way to assign a cost for an anesthesiologist’s services may heavily impact the cost model. We assumed that having an anesthesiologist provide epidural analgesia is an incremental (variable) cost to society (measured at Medicare rates). Incremental or variable cost implies that the professional costs for anesthesia increase as more parturients receive epidural analgesia. We assumed this because, from society’s point of view, there is a cost for the anesthesiologist’s time and expertise in placing the epidural catheter and managing the epidural analgesia. This implies that a physician’s time spent managing epidural analgesia, or complications thereof, could be otherwise spent were it not for the epidural analgesia or the resultant complication (e.g., postdural puncture headache).

In some settings, the anesthesiologist is assigned to the labor and delivery suite exclusively, or the hospital pays a predetermined amount for coverage of the obstetric suite, regardless of the number of patients with epidural analgesia. In this situation, the professional cost might be considered a fixed cost (a cost that does not change in proportion to the number of patients receiving epidural analgesia), at least for a cost analysis done from the perspective of the hospital.

From society’s perspective, however, the anesthesiologist’s professional cost is likely to be considered variable. By definition, variable costs vary with the volume of activity (the number of patients that request epidural analgesia at a given labor and delivery suite). If the number of patients requesting epidural analgesia is only a few a day, then those patients might be able to be “covered” by anesthesiologists assigned to the operating suite. In this circumstance, activities (e.g., surgical cases in the main operating suite) outside of the labor and delivery suite may decrease the availability of an anesthesiologist to care for laboring patients desiring epidural analgesia.

In this study, the cost of professional time spent to deliver epidural analgesia was considered an incremental cost to society because it represents someone being unavailable for other patient care. This is consistent with the principle that the cost of a medical service (from society’s point of view) is the result of society having

### Table 6. Cost of Anesthesiologist’s Care

<table>
<thead>
<tr>
<th></th>
<th>Cost of Anesthesiologist’s Care</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vaginal delivery</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intravenous analgesia</td>
<td>$0</td>
<td>5 base units start up, 4 units first hour and 1 unit/h × 5 h</td>
</tr>
<tr>
<td>Epidural analgesia</td>
<td>$238</td>
<td></td>
</tr>
<tr>
<td><strong>Cesarean section</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intravenous analgesia</td>
<td>$204</td>
<td>7 base units start up and 5 units (time)</td>
</tr>
<tr>
<td>Epidural analgesia</td>
<td>$340</td>
<td>7 base units start up (cesarean section), 4 units (first hour of epidural) and 1 unit/h × 4 h of epidural, and 5 units for cesarean section time</td>
</tr>
</tbody>
</table>

Anesthesia professional costs are calculated based on a $17/unit (Medicare reimbursement).

---

Anesthesiology, V 92, No 3, Mar 2000
given up the opportunity to use those resources for some other purpose. This follows from health economic theory, which states that resources are scarce, and if a medical intervention is valued as a less worthwhile expenditure than other medical interventions (i.e., below some threshold of cost-effectiveness), then medical resources spent by health maintenance organizations and the Federal government could be redirected to other areas.

**Nurse Staffing**

Similar concepts about assigning costs to the work of medical providers apply to consideration of nursing costs. The primary analysis assumed that changes in intensity of nursing care in the labor and delivery suite are reflected in nursing personnel costs, as reflected by an hourly cost for nursing care. A second analysis assumed that nurse staffing does not change based on the number of clinical interventions. This may be relevant for a cost analysis from a health plan's point of view, which would include different cost estimates. For example, from the health plan’s perspective, if nurses are salaried, a complication that required more nursing surveillance may not be an extra cost, unless an additional staff person is required.

**Epidural Analgesia and Operative Delivery**

Recent studies show no increase in rate of cesarean section with epidural analgesia in labor, although some earlier studies had shown a relationship between epidural analgesia and the incidence of cesarean section. It is difficult to separate an association between epidural analgesia and cesarean section occurring because patients receiving epidural analgesia have a priori dysfunctional labor from a cause-and-effect relationship. Selection bias (women who select epidural analgesia for labor have different labor patterns than women who do not) is a problem in nonrandomized studies of epidural versus intravenous analgesia; the results of randomized trials are complicated by high noncompliance rates with randomization. Our analysis of the literature for complications is consistent with a recent metaanalysis that found that patients with epidural analgesia had longer first and second labor stages, were more likely to have instrumental deliveries (unless only the indication of dystocia was considered), and gave birth to neonates that were less likely to need naloxone.

Some health plans have attempted to reduce utilization of epidural analgesia for labor pain. For example, TennCare, a state-funded health insurance plan in Tennessee, has denied reimbursement for epidural analgesia for labor. After instituting this nonreimbursement policy, the rate of epidural anesthesia for primigravida patients decreased from 80% to 33%, with too few patients to warrant a statistical analysis on whether the rate of cesarean section changed. No economic data were reported.

**Limitations**

As with any cost model, the conclusions depend on critical assumptions regarding costs and probabilities. For example, we did not factor in incremental costs related to the newborn nursery caring for a baby should the mother suffer a complication and be unable to care for the child. Nevertheless, our findings appear to be stable over a range of plausible assumptions.

Our cost analysis was for a healthy parturient having a routine delivery. This study did not assess subgroups of patients that may benefit from epidural analgesia for labor pain for medical conditions (e.g., patients with cardiac disease or preeclampsia). If the patient had coexisting disease that made epidural analgesia even more favorable, then that would change the benefit side of our cost analysis. Also, in some patients, epidural analgesia may increase the likelihood of vaginal delivery (e.g., trial of labor in women with a history of previous cesarean section). In addition, patients may not elect vaginal birth after cesarean delivery if epidural analgesia is not available. Finally, our model does not include other analgesic regimens for labor pain, which would need to be studied separately. For example, the benefit side of our cost analysis might have been different had we evaluated the impact on outcomes of either using more dilute concentrations of local anesthetics (which are increasingly being used in epidural analgesia for labor) or using a combined spinal–epidural technique to relieve labor pain.

In conclusion, the expected estimated cost per patient to society of epidural analgesia for relief of labor pain ranges from $259 to $338 (depending on how costs of nursing interventions in the labor and delivery suite are calculated) greater than the expected cost of intravenous analgesia for labor pain. This cost difference results from increased professional fees and complication costs associated with epidural analgesia. How the cost of the anesthesiologist is calculated affects how much more costly epidural analgesia is relative to intravenous analgesia. Review of the literature confirms that epidural analgesia provides superior pain relief quantified by one study to be 40 mm better on a 100 mm scale during the first stage of labor and 29 mm better during the second stage of labor. Patients, physicians, and society need to weigh the value of

Anesthesiology, V 92, No 3, Mar 2000
improved pain relief from epidural analgesia relative to the increased cost of epidural analgesia.

References


Anesthesiology, V 92, No 3, Mar 2000