A Rational Approach to Ligation of Patent Ductus Arteriosus in the Neonate*


During a 23-month period, 25 premature infants underwent ligation of a patent ductus arteriosus performed in the neonatal intensive care unit utilizing a limited posterolateral muscle-retracting incision. This approach afforded adequate exposure with minimal surgical time and trauma. All infants manifested severe respiratory distress and congestive heart failure. Both standard and contrast echocardiographic studies were used for noninvasive preoperative evaluation. Echocardiographic study proved to be a highly reliable and sensitive indicator of ductal patency. Eight infants (32 percent) died at 8 to 225 days of age. The primary cause of death was progressive pulmonary disease with subsequent failure of multiple organ systems. Seventeen (68 percent) of the 25 infants survived to leave the hospital. Advantages of ligation of a patent ductus arteriosus in the neonatal intensive care unit include the elimination of problems of transportation (thermoregulation, ventilation, and loss of lines) and continuity of ongoing care and monitoring. The standard facilities of the neonatal intensive care unit proved completely satisfactory for ligation of a patent ductus arteriosus. Ligation in the neonatal intensive care unit is suggested to minimize potential complications of care in the operating room and transport of these critically ill infants.

Patent ductus arteriosus is a frequent complication in preterm infants weighing less than 1,750 gm (3 lb 14 oz) at birth; approximately 60 percent of these have associated idiopathic respiratory distress syndrome.1 The premature infant with a patent ductus arteriosus may often have respiratory insufficiency and concurrent pulmonary congestion.2 Although the exact causative mechanism of patent ductus arteriosus is still unclear, persistent arterial hypoxemia, decreased responsiveness of the ductal tissue to oxygen,3,4 and reduced ductal cholinergic innervation5,6 are possible contributing factors.

In most cases, spontaneous closure of the patent ductus eventually occurs;5,6 however, when it remains patent and pulmonary vascular resistance is low, the resulting left-to-right shunt may produce congestive heart failure manifested clinically by bounding pulses, hepatomegaly, increasing hypoxemia, and hypercapnia secondary to pulmonary edema. Radiographically, cardiac enlargement and pulmonary engorgement may be evident. Several recent reports describe indications and results of early ligation of a patent ductus arteriosus when signs and symptoms of congestive heart failure supervene on those of the infant respiratory distress syndrome.2,6,7,8 Echocardiographic study shows left atrial and occasional left ventricular enlargement in patients with significant shunts. Patients who have undergone ductal ligation show a decrease in left atrial and left ventricular dimensions to normal.

In order to avoid complications from transporting these infants, all premature infants undergoing ligation of a patent ductus arteriosus during the past 23 months had surgery performed in the neonatal intensive care unit. This report summarizes the recent results with this technique.

**MATERIALS AND METHODS**

Data were obtained from a retrospective review of the records from 25 consecutive premature infants undergoing ligation of a patent ductus arteriosus in the Neonatal Intensive Care Unit of the University of Arizona Health Sciences Center, Tucson, from January 1978 to February 1978. Standard clinical criteria for the diagnosis of patent ductus arteriosus included a harsh systolic precordial and subclavicular murmur which radiated to the left side of the back, a hyperactive precordium, and bounding pulses. Cardiac catheterization or aortographic studies were not performed on any patient. Chest roentgenograms often showed cardiomegaly and engorged pulmonary fields. Echocardiographic studies demonstrated left atrial enlargement in all. Contrast echocardiographic studies showed a left-to-right shunting patent ductus arteriosus in patients without a murmur.9

*From the Section of Cardiovascular and Thoracic Surgery, Department of Surgery, and the Section of Pediatric Cardiology, Department of Pediatrics, University of Arizona Health Sciences Center, Tucson. Manuscript received August 7; revision accepted November 14.

Reprint requests: Dr. Salomon, University of Arizona Health Sciences Center, Tucson 85724
Criteria for surgical ligation of the patent ductus arteriosus in these neonates included deterioration of pulmonary function, as evidenced by increasing hypoxemia, hypercapnia, and decreased pulmonary compliance. Congestive heart failure that was unresponsive to therapy with restriction of fluids, digitalis, and diuretic drugs was a major indication for surgery. Echocardiographic left atrial enlargement was present in all.10.11,3 All infants were receiving therapy with digitalis, diuretic drugs, and restriction of fluids and required ventilatory support (Bourns). Weights at birth ranged from 750 to 1,600 gm (1 lb 10 oz to 3 lb 8 oz), with a mean of 1,000 gm (2 lb 3 oz). Gestational age ranged from 25 to 34 weeks, with a mean of 31 weeks. Age at operation ranged from 2 to 21 days (mean, eight days), and the average weight at operation was 1,100 gm (2 lb 7 oz).

The idiopathic respiratory distress syndrome was judged to be severe in all 25 infants, with preoperative arterial carbon dioxide tension averaging 58 mm Hg and a fractional concentration of oxygen in the inspired gas greater than 0.5 to 0.6 to maintain an arterial oxygen pressure greater than 50 mm Hg while on therapy with continuous positive airway pressure.

Either umbilical or radial arterial catheters were in place before surgery in all infants for monitoring arterial blood gas levels and administration of fluids. A summary of clinical data from the group of patients is presented in the following tabulation, showing the number of patients in each category:

<table>
<thead>
<tr>
<th>Gestational age, weeks</th>
<th>26-29</th>
<th>30-33</th>
<th>34-36</th>
<th>37-40</th>
<th>41-42</th>
<th>43 or more</th>
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<tbody>
<tr>
<td>Weight at birth, gm</td>
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<td>&lt;1,000</td>
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<td>1,000-1,500</td>
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<td>1,500-2,000</td>
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<tr>
<th>Age at operation, weeks</th>
<th>&lt;1</th>
<th>1-2</th>
<th>&gt;2</th>
<th>3-5</th>
<th>6-8</th>
<th>9 or more</th>
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<tr>
<td>Weight at operation, gm</td>
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<tr>
<th>Respiratory distress syndrome</th>
<th>Moderate</th>
<th>Severe</th>
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<tr>
<td>Early postoperative status (within 48 hours)</td>
<td>Marked improvement</td>
<td>Mild improvement</td>
</tr>
<tr>
<td>Outcome</td>
<td>Died</td>
<td>Discharged</td>
</tr>
</tbody>
</table>

Surgical Technique

Before surgery, each patient was typed and crossed for 250 ml of packed red blood cells, and therapy was begun with moderate doses of ampicillin and gentamicin. With anesthesiologist, cardiologist, and neonatologist in attendance, the infants were paralyzed with pancuronium bromide, were placed in a right lateral decubitus position, and were prepped and draped. The settings on the respirator were unchanged, but the infants were ventilated with 100 percent oxygen while the chest was open.

Using sterile technique the chest wall was infiltrated with a 0.1 percent solution of lidocaine hydrochloride and was opened in the left third intercostal space. The limited incision was placed posterior to the latissimus dorsi muscle. The superficial fascia was elevated, and the rhomboid and trapezius muscles were retracted superiorly (cephalad) and the latissimus dorsi muscle anteriorly in a true muscle-retracting incision. Using a transverse approach, the ductus was encircled and singly ligated with a 2-0 or 0 silk ligature. In most cases, as the chest was closed, the air was evacuated from the thorax using a 12F Robinson’s catheter, which was then withdrawn. Occasionally, a 12F to 14F chest tube (Argyle) was left in place for 12 to 24 hours after surgery if an air leak was present or when the infant required therapy with very high airway pressures.

Throughout the procedure, which averaged 25 minutes, all personnel were masked, gowned, and scrubbed, and the infant remained in an open warmer to maintain body temperature. All equipment for pediatric resuscitation, including a defibrillator and drugs, were immediately available. The patient’s heart rate, rhythm, rectal temperature, and arterial pressure were constantly monitored.

Results

There was one early death which occurred in the period immediately after surgery. One infant with a gestational age of 28 weeks, weighing 750 gm (1 lb 10 oz), underwent ligation of a patent ductus arteriosus at one week of age. The child was in extremis at the time of surgery and died of progressive bradycardia within one hour following operation. Two nonfatal complications occurred in another infant; dislodgment of an endotracheal tube resulted in transient hypoxia, and hemorrhage from laceration of the ductus necessitated rapid transfusion of blood. There was no other incidence of hypothermia, hypotension, pneumothorax, or overloading with fluid in this series. There were no long-term complications such as infection of the wound or injury to the phrenic or recurrent laryngeal nerves.

Only four of the 25 infants showed marked improvement after surgery and could be weaned from ventilatory support within two days. Thirteen (52 percent) of the 25 patients showed mild but definite improvement clinically and radiologically and were eventually weaned from mechanical ventilatory support and discharged. Eight (32 percent) of the 25 patients were not significantly improved within one week of surgery and eventually died between 1 to 213 days after surgery (ages, 8 to 225 days). At autopsy, all of the infants who died showed evidence of severe bronchopulmonary dysplasia, and two had intracranial hemorrhage. The mean gestational age or weight at birth was not significantly different between those patients who survived and those patients who eventually died.
DISCUSSION

Several recent reports emphasize the efficacy and advisability of ligation of a patent ductus arteriosus in premature infants with idiopathic respiratory distress syndrome complicated by congestive heart failure secondary to a large left-to-right shunt. The multiple indications for surgical intervention are well summarized by Rittenhouse et al. In general, premature infants with a patent ductus arteriosus and left-to-right shunting who are already receiving digitalis and diuretic drugs and who require mechanical ventilatory support should have ligation of the patent ductus arteriosus if (1) they show evidence of progressive deterioration of pulmonary function and (2) signs and symptoms of uncompensated pulmonary congestion.

Varying success has been reported with medical measures for inducing ductal constriction using indomethacin, which is a potent inhibitor of prostaglandin E; synthetase. Nonetheless, recent experience suggests a failure rate of 30 to 40 percent in infants weighing less than 1,100 gm (2 lb 7 oz); these patients still require surgical ductal ligation.

The diagnosis of patent ductus arteriosus was made on the basis of clinical and plain roentgenographic findings; aortographic study was not performed in any case. The expected patent ductus arteriosus was present in every patient undergoing surgery and was usually as large in external diameter as the descending aorta. In patients with silent patent ductus arteriosus, contrast echocardiographic studies proved the presence of a left-to-right shunting ductus. There was no situation in which aortographic studies would have altered the surgical indications or approach. Other studies corroborate these findings.

Echocardiographic studies provided an additional noninvasive method of determining left atrial size, which correlates well with the need for ductal closure. The ratio of left atrial diameter to aortic diameter averaged 1.56 before surgery and decreased to 0.96 within the first 24 hours after surgery.

In a review of the literature on ligation of patent ductus arteriosus in premature infants, Rittenhouse et al noted an overall mortality of 35 percent (59 deaths among 168 patients); the same figure was obtained in the present study. Over two-thirds of the infants died from ongoing pulmonary insufficiency progressing to bronchopulmonary dysplasia. Other problems of prematurity, such as sepsis, necrotizing enterocolitis, intracranial hemorrhage, and neurologic deficiencies, are additional causes of morbidity and mortality.

In these precariously ill neonates, the simplest and least meddlesome intervention that accomplishes ductal closure seems preferable. Performing an operation in the neonatal intensive care unit affords no significant disadvantage and was not attended by any immediate or long-term complications. The potential problems of transportation of the infant to the operating room to reestablish the setting already present in the neonatal intensive care unit are eliminated. Expensive and often cumbersome vehicles for transport are unnecessary. The risk of transportation-related problems, such as breaks in the continuity of monitoring, thermoregulatory instability, loss of lines, inadequate ventilation, and imbalance of fluids, is greatly reduced. Oxnard et al recently reported a similar technique with equal enthusiasm. The infants are already intubated and in open radiant warmers and are continuously monitored for arterial pressure, heart rate, rhythm, temperature, and respiratory rate. The limited muscle-retracting posterior incision through the "auscultatory triangle" allows a relatively atraumatic entry into the chest, with adequate exposure. It is a cosmetic incision which preserves the integrity of the musculature of the chest wall.

In summary, ligation of a patent ductus arteriosus in premature infants can be performed in the neonatal intensive care unit with a minimum of surgical morbidity and mortality. Over one-half of these infants, even those with severe pulmonary insufficiency, can survive to leave the hospital. Ligation of the patent ductus arteriosus eliminates heart failure due to the large left-to-right shunt. The procedure can be accomplished in the neonatal intensive care unit with added safety and convenience, without significant disadvantage.

REFERENCES