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Extremely Low Birth Weight Infants with Patent Ductus Arteriosus: Searching for the Least Invasiveness

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ABSTRACT

Patent ductus arteriosus (PDA) is an important problem in premature infants. Extremely low birth weight infants (ELBWI) are so fragile with respect to surgical stress that minimally invasive procedures are required. We report 26 ELBWI cases with PDA who underwent surgical closure. All had failed indomethacin treatment, or it had been contraindicated. The mean gestational age at birth was 27 weeks (range, 24-38 weeks), and the mean birth weight was 960.96 g (range, 710-1440 g). The mean age at operation was 18.06 days (range, 7-34 days), and the mean body weight at operation was 989.42 g (range, 680-1460 g). There was no surgery-related mortality or morbidity. Our surgical procedures consisted of posterior muscle-sparing thoracotomy, clipping the PDA and no ligation, and closing the thorax without a tube thoracostomy. Muscle-sparing thoracotomy reduces the likelihood of long-term physical impairment and deformity, the clipping technique minimizes the dissection of surrounding PDA tissue, and the thorax is closed without a tube. Nursing care is simplified, costs are reduced, and the number of chest x-rays needed postoperatively is reduced. We believe that surgical closure of PDA without chest tube drainage can be accomplished safely in premature infants.

INTRODUCTION

Extremely low birth weight infants (ELBWI) (500 to 1500 g) account for approximately 1% of all live births but >60% of all neonatal deaths [Greene 2002]. In these extremely premature neonates, the frequency of patent ductus arteriosus (PDA) is approximately 30% [Van Overmeire 2000].

Left-to-right shunting through the PDA causes increased pulmonary blood flow and steal from the systemic circulation. These hemodynamic changes may be responsible for the comorbid conditions associated with PDA: prolonged ventilator dependence and chronic lung disease [Bancalari 2001], pulmonary hemorrhage [Garland 1994], intraventricular hemorrhage [Jim 2005], necrotizing enterocolitis [Coombs 1990], and retinopathy of prematurity [Wheatley 2002].

Because of these life-threatening complications, PDA should be closed, but the management of PDA in these high-risk infants remains an area of controversy. The optimal management of PDA in neonates weighing <1000 g is still under debate. What is the timing of closure? Should medical or surgical treatment be used? If medical, how many times or how long should it be tried? [Vida 2009]. When medical therapy fails, however, we do know that it should be treated surgically. We report our surgical procedure for PDA closure to be among the least invasive for ELBWI.

MATERIALS AND METHODS

Twenty-six ELBWI underwent surgical closure of PDA at our hospital. The mean gestational age at birth was 27 weeks (range, 24-38 weeks), and the mean birth weight was 960.96 g (range, 710-1440 g). The mean age at operation was 18.06 days (range, 7-34 days), and the mean body weight at operation was 989.42 g (range, 680-1460 g). Indomethacin treatment was contraindicated for 1 infant because of renal impairment soon after birth. Another 25 infants had undergone indomethacin, but it failed to close the PDA. All patients were intubated and supported by mechanical ventilation, owing to respiratory distress syndrome. All infants were monitored with invasive and/or noninvasive techniques. General anesthesia was induced intravenously with 0.01 mg/kg atropine, 0.1 mg/kg vecuronium, 2 µg/kg fentanyl, and 0.15 mg/kg ketamine. Anesthesia was maintained with 1% sevoflurane, 40% to 60% oxygen in air, fentanyl, and vecuronium. The infant was put in a right lateral position. Posterior muscle-sparing thoracotomy with a skin incision of 2.0 to 2.5 cm was performed (Figure). The plane between the latissimus dorsi and trapezius muscle was opened in the triangle of auscultation. The scapula was lifted easily from the chest wall by dissecting and freeing the serratus anterior. The fourth intercostal space was then identified and opened, with care taken not to damage the lung, especially when the infant was

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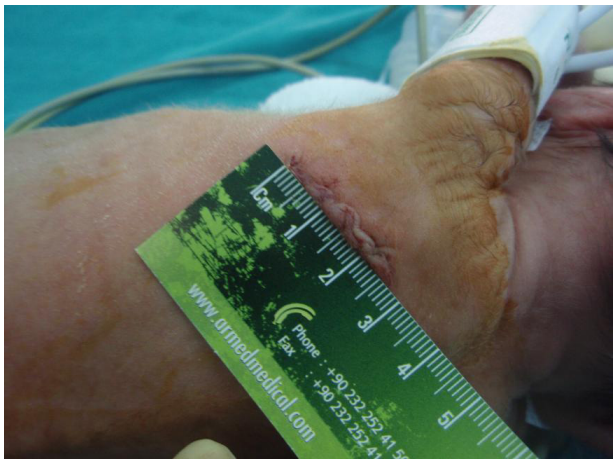
ventilated by high-frequency oscillation. A Weitlaner retractor was used for widening the intercostal space. The lung was retracted forward modestly just so the PDA could be identified. Minimum and meticulous dissection was carried out above and below the ductus just sufficiently to place a clip.

Care was taken to avoid compromising the recurrent nerve. After inflating the lungs and keeping them in inspiration, the pleural cavity was closed without placing a chest tube.

Blood loss was minimal, and there was no pneumothorax, chylothorax, or chest tube insertion in the intensive care unit. There were no complications associated with the surgical procedure. All infants survived and were discharged without supplemental oxygen. One infant death occurred in the sixth postoperative month; another infant died from intraventricular hemorrhage and sepsis.



Posterior muscle-sparing thoracotomy with skin incision (2.0–2.5 cm).

DISCUSSION

Symptomatic PDA is diagnosed in as much as 30% of hospitalized ELBWI. Moreover, 56% of preterm infants born at a gestational age of <24 weeks have respiratory distress syndrome [Kida 2002]. Since its introduction in 1946, indomethacin has been the initial treatment of choice and has been considered effective. The success rate of indomethacin therapy for PDA closure is 79% if the birth weight is <1750 g [Gersony 1983]; however, the failure rate can be as high as 40% to 50% if the birth weight is <800 g [Trus 1993]. In addition, indomethacin may increase the incidence of necrotizing enterocolitis and bowel perforation in extremely premature infants [Grosfeld 1996]. Critically ill infants cannot tolerate these side effects.

Although the ideal treatment and timing of PDA repair is subject to much debate [Knight 2001], prompt ductal closure is generally accepted to be desirable to minimize the deleterious effects of PDA in premature infants [Cassady 1989]. The gold standard is repeating indomethacin twice. If that fails, surgical closure is necessary. Delaying surgical closure may increase the likelihood of developing morbidity or mortality [Little 2003; Vida 2009]. Surgical closure should be thought of as the primary form of treatment in very premature neonates [Grosfeld 1996; Cassady 1989]. One randomized study has demonstrated that early surgical closure of a PDA is beneficial in preterm infants who weigh <1500 g and require ventilator support [Cotton 1978]. Even though some studies have revealed no significant difference in the survival rate between indomethacin therapy and surgical closure, the complications of indomethacin treatment and prolonged intubation have been shown to have a significant impact on the surgical outcome [Chang 2005]. Congestive heart failure induced by PDA may compromise the general condition of the premature neonate [Chang 2005]. To decrease the complications of PDA, we suggest early closure of PDA by surgery instead of medical treatment in very low birth weight premature infants. Because all of our patients had either failed indomethacin therapy or had a contraindication to its use, surgical closure was the alternative treatment for these infants. ELBWI are so vulnerable to surgical invasion that the surgeon should take their physiology into account and perform less-invasive procedures. We have had a long-term interest in muscle-sparing thoracotomy (2-2.5 cm) and clip closure. In the last 26 cases, we have performed the clip closure without tube thoracostomy. The surgical intervention itself, with its thoracotomy and spreading of the ribs, may contribute to postoperative ventilator dependence. Left lung compression during closure may cause intrapulmonary hemorrhage and/or prolonged atelectasis. It is well known that adult thoracotomy patients may experience prolonged postoperative pain, with its associated risk of poor respiratory effort. Taking into account all these factors, we have adopted muscle-sparing thoracotomy (2-2.5 cm) and clip closure without tube thoracostomy. Conventional standard thoracotomy divides the major muscles of the chest wall, which causes denervation atrophy, fibrosis, and pulmonary dysfunction. Furthermore, it may cause subsequent long-term physical impairment and deformity. Muscle-sparing thoracotomy not only is useful when combined with clip closure and without tube thoracostomy but also is beneficial for the long-term quality of life of premature infants.

There are different techniques, each of which has its own advantages and drawbacks. The clip technique obviously has some advantages of minimal lung retraction, minimal dissection of the ductus, and reduction in the risk of vascular injury and bleeding, which contributes to avoidance of hemodynamic deterioration [Trus 1993]. A literature review described a residual ductal patency rate of 3% to 5% in patients who had suture ligation of a PDA [Panagopoulos 1971], and it is noteworthy this rate is as high as 22% by Doppler color flow echocardiography, even without residual PDA auscultatory findings [Sorensen 1991]. Our experience indicates no evidence of postoperative ductal patency by echocardiography. We believe that clip closure is also reliable for definitive closure of PDA; however, left recurrent laryngeal nerve injury occurs infrequently as a complication of ductal ligation. A paralyzed left vocal cord has been identified in 4% of the patients weighing <1500 g and undergoing ductal closure with a clip [Fan 1989]. We have not encountered any complication associated with the procedure.

Miles et al [1995] have also described the safety and cost-effectiveness of PDA closure without a tube thoracotomy, but they placed suction into the pleural cavity before closing the

thorax. Although Mavroudis et al [1994] reported the frequencies of chylothorax and pneumothorax to be both 0.6% in a cohort of 1108 patients, excluding premature babies. Once such a complication occurs, however, serious problems arise for high-risk premature infants [Mavroudis 1994]. We have not experienced any complications, nor have we placed a chest tube postoperatively in the intensive care unit.

Two less-invasive procedures have been described for interrupting a PDA in small infants. One is percutaneous transcatheter ductal closure. Although a Rashkind occluder was successfully implanted for PDA closure in a 3.5-kg infant [Rashkind 1979], this technique has limited application for newborns, owing to the size and relatively large delivery system. Haneda et al [2001] reported a transcatheter PDA coil closure in premature infants weighing 1180 g. Technological advances in the catheter device will make it possible to treat premature infants.

For smaller infants, video-assisted thoracotomy with clip ductal closure is another method, and it might be the most promising method for treating PDA in premature infants. Forster [1993] reported a new thoracoscoplc technique in which thoracoscopic PDA clipping was performed in 3 premature infants weighing 750, 950, and 1000 g. There are now some concerns about using the video-assisted thoracotomy technique in premature infants, but the technique we have described in this article may follow it in time.

CONCLUSION

The management of PDA in ELBWI remains an area of controversy. Indomethacin has been the initial treatment of choice for ELBWI with PDA. Excessive morbidity is associated with prolonged use of indomethacin, however, and higher failure rates of PDA closure have been reported with indomethacin therapy, especially in ELBWI. We believe our surgical technique is less invasive and provides beneficial outcomes for ELBWI who are at higher risk of medical failure.

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