

Comparison of suture ligation and clip application for the treatment of patent ductus arteriosus in preterm neonates

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Objective: We reviewed the experience of 2 centers performing surgical ligation of patent ductus arteriosus in preterm neonates to identify whether the choice of surgical technique—suture ligation or clip application—affected outcome.

Methods: Between 2000 and 2005, 67 newborn infants had open surgical closure of patent ductus arteriosus: 33 by suture ligation and 34 by clip application. The groups were similar in age and sex.

Results: The average length of the procedure was 55.8 ± 13.7 minutes for suture ligation and 30.8 ± 8.7 minutes for clip application ($P < .05$). Six neonates had intraoperative bleeding in the suture ligation group. Four patients had significant postoperative complications in the suture ligation group, compared with 2 in the clip application group.

Conclusions: This study demonstrates that clip application results in a significant reduction in the operative time and, possibly, in less morbidity.

A patent ductus arteriosus (PDA) is commonly present in premature infants with hyaline membrane disease.¹⁻⁴ In many low-birth-weight infants, the ductus arteriosus fails to close spontaneously, and they subsequently show signs and symptoms of poor perfusion and heart failure.⁵⁻⁷ Management of hemodynamically significant PDAs in preterm neonates is directed at closing the duct early to avoid the effects of left-to-right shunting.⁸⁻¹¹ This can be achieved by pharmacologic treatment or with surgical intervention.

Since the first successful surgical ligation by Gross and Hubbard¹² in 1939, many techniques have been described.¹³⁻¹⁶ Until recently, open surgical ligation has been unchallenged as a safe and effective surgical technique for ductal closure.¹⁷ The classic open surgical technique involves complete dissection around the ductus and double ligation with a multifilament ligature. A modification of the technique, to reduce the amount of dissection around the thin and friable ductus (and to reduce the risk of catastrophic bleeding), involves the application of metal surgical clips.^{18,19} The purpose of this study was to compare the two techniques in neonates with hemodynamically significant PDA that necessitated surgical closure.

Patients and Methods

This study involved a retrospective review of the clinical and operative records of neonates who had open surgical closure of PDA at 2 tertiary care pediatric centers (Waikato Hospital, Hamilton, and Christchurch Hospital, Christchurch, New Zealand) during a 5-year period. Six pediatric surgeons operated on all the patients. Patients were not selected randomly to either procedure but were treated according to the preference of the surgeon. In all cases, the diagnosis of PDA was confirmed with 2-dimensional echocardiography. With patients under general anesthesia, arterial lines were placed at the discretion of the anesthesiologists, and

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Abbreviations and Acronyms

CA	= clip application
PDA	= patent ductus arteriosus
SL	= suture ligation

transcutaneous oxygen saturation monitoring was applied to the lower limbs. Infants were positioned for a left posterolateral thoracotomy through the fourth intercostal space.

In the suture ligation (SL) group, the mediastinal pleura was incised along the aorta and ductus and reflected medially. The left recurrent laryngeal nerve was kept medially. The ductus was cleared of its surrounding adventitial tissue circumferentially to allow the placement of a right-angle clamp behind it to pass a silk ligature. The duct was closed by using 2 silk ligatures. In the clip application (CA) group, the left recurrent laryngeal nerve was identified and protected by keeping it medially, and after minimal dissection above and below the aortic ends of the ductus, one or two medium titanium clips (LIGACLIP; Ethicon Endosurgery Inc, Cincinnati, Ohio) were applied to obliterate the PDA. The chest was closed without a chest drain. After surgery, patients were managed in the neonatal intensive care unit.

The outcomes measured included the length of operation, intraoperative and postoperative morbidity, and requirement for transfusion. Data were compared with a 2-tailed Student *t* test. Ninety-five percent confidence intervals were calculated, and statistical significance was attributed at $P \leq .05$.

Results

There were 67 patients in the 5-year study population. The results are summarized in Table 1. The demographics of the 2 groups were similar. The duration of operation for SL was significantly longer than for CA. In the SL group, intraoperative bleeding occurred in 6 infants, and 4 had significant

postoperative complications. All patients with a pneumothorax required intercostal drains, and the patient with chylothorax required ligation of a leaking lymphatic duct after 3 weeks and made an uneventful recovery. Two patients in the SL group required postoperative blood transfusion. Ninety-five percent confidence intervals for the differences in means demonstrated a significant difference ($P < .05$) between operative times; however, the apparent differences in the intraoperative and postoperative complications between the 2 groups did not reach statistical significance.

Discussion

The surgical closure of PDA in premature infants who do not respond to pharmacologic treatment has been shown to be effective and relatively safe.²⁰⁻²² Some surgeons use silk ligation of the ductus,^{23,24} whereas others have advocated CA.^{18,19,25} The results of this study show some benefits of CA over SL.

In preterm infants, tissues are thin and friable around the ductus. In SL, this tissue has to be completely dissected around the circumference of the ductus, so that a right-angle clamp can be placed behind it to grasp the silk ligature. This can be hazardous and may result in tearing of the friable ductus. Occasionally, the ductus may tear because excessive tension is placed on the ductus at the time of its ligation. Sometimes, because of the small size of the thoracic cavity, the surgeon is physically unable to get his or her fingers into the chest cavity, and this makes gentle ligation of the ductus more difficult. Once the ductus is torn, the bleeding that ensues may be difficult to control and can be life-threatening. The CA technique requires minimal dissection and reduces the risk of this complication. In our study, 6 (18%) SL patients had intraoperative bleeding, which was potentially life-threatening. Technically, CA is an easier operation to perform than SL. The reported residual ductal patency rate on auscultation after SL is 3% to 5%^{17,26,27}; in our study, there was no postoperative ductal patency in either group, and this was confirmed by the absence of murmur. Thus, there was 100% successful closure of the duct with both techniques.

SL is a longer operation than CA. It necessitates longer retraction of the left lung, thus prolonging the difficulties of ventilation in an already-compromised neonate. An operative technique that requires a shorter time may be beneficial for these sick neonates. The shorter operative time for CA probably resulted from the need for less dissection and contributed to minimal perioperative complications.

Vocal cord paralysis in premature infants undergoing PDA closure has been reported with both techniques. Fan and colleagues²⁸ identified paralysis of the left vocal cords in 4% of patients weighing less than 1500 g who had CA, and Davis and colleagues²⁹ reported this complication in 5.2% of patients closed by SL. In our study, its occurrence in 1 patient who had CA may have been due to use of

TABLE 1. Summary of results

Parameter	SL group	CA group
No. Patients	33	34
Age at operation (d)	14.2 ± 1.8	15.2 ± 2.5
Weight at operation (g)	837 ± 277	850 ± 257
Male:female ratio	1.4:1	1.5:1
Size of duct on echocardiography (mm)	2.8 ± 0.7	2.7 ± 0.6
Operating time (min)	55.8 ± 13.7*	30.8 ± 8.7*
Intraoperative bleeding	6 (18%)	0
Postoperative morbidity	4 (12%)	2 (6%)
Pneumothorax	2	1
Left recurrent laryngeal nerve injury	1	1
Chylothorax	1	0
Eventration of diaphragm, left side	1	0
Blood transfusions	2 (6%)	0

SL, Suture ligation; CA, clip application. Results are expressed as mean ± SD. * $P < .05$.

electrocautery during dissection or to the entrapment of the nerve in the clip. This highlights the importance of early identification of the nerve, careful dissection of periductal tissues, and careful clip placement. The incidence of pneumothorax necessitating de novo drain placement was similar in both groups, and a similar finding has been reported by others.³⁰ Complications such as chylothorax and phrenic nerve injury, although comparable in incidence to other studies,^{11,17,30} can pose a high risk for preterm neonates.

The relatively small number of patients in the study means that no statistically significant difference in perioperative morbidity could be established between SL and CA. Nevertheless, our experience would indicate that CA is the preferred technique because of its relative technical simplicity and shorter operative time.

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