Closure of the Patent Ductus Arteriosus
With a Ligaclip Through a Minithoracotomy*

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This article describes a technique which allows the patent ductus arteriosus (PDA) to be closed through a minithoracotomy. It combines a simple method of inducing atelectasis with Ligaclip closure of the PDA through a subaxillary incision. It was used successfully in 11 children and adolescents.

Since the report of Gross and Hubbard, the patent ductus arteriosus (PDA) generally has been approached through a lateral or posterolateral thoracotomy because of its location deep in the chest. While a thoracotomy provides good access and sufficient working space for the surgeon, postoperative pain from a thoracotomy wound can contribute significantly to postoperative morbidity. Wound size can influence the amount of pain that is experienced in the postoperative period. By involving minimal muscle division, a mini thoracotomy could be more comfortable than a standard thoracotomy (Fig 1). In the abdomen, reduction in wound size through laparoscopic techniques has resulted in a reduction in postoperative discomfort. In the chest, technical factors have prevented the routine use of a smaller incision, such as a minithoracotomy, for closure of the PDA. These have included the absence of techniques for providing adequate visibility and lung retraction as well as a suitable method of closure of the ductus through the minithoracotomy. Gunning described Ligaclip closure of the ductus through a thoracotomy in neonates. His technique, which requires much less dissection and working space, has simplified the procedure of ductal closure. This article describes a further modification of the technique which has allowed the ductus to be approached and closed through a minithoracotomy.

Patients and Methods

Eleven patients with a PDA demonstrated angiographically or by Doppler echocardiography were operated on after consent was obtained. There were 3 males and 8 females, and their ages ranged from 3 months to 15 years. The patients were anesthetized and intubated with a single-lumen endotracheal tube. An arterial line was used for monitoring of arterial pressure and blood gas levels, and a pulse oximeter was used to monitor oxygen saturation. The patients were positioned in the left lateral position with the arm abducted over the head. In the infants and younger children, the arm rested on a soft padding placed between the arm and the head.

In the older children and adolescents, an adjustable arm rest was used. In addition to the operation room lamp, a headlight was used by the surgeon. A small transverse incision was made in the axilla over the second intercostal space (3 to 5 cm in children and 4 to 7 cm in adolescents). The pleural space was entered and atelectasis in the left upper lobe (LUL) was induced by inserting a roll of 3-inch gauze into the apex of the chest cavity and thereby gently compressing the LUL. The gauze was left in situ for several minutes while the patient was gently hand-ventilated. The arterial blood gas levels and pulse oximeter were closely monitored for hypoxia. The rolled gauze was removed and the LUL was then inspected for collapse; the gauze was reinserted for an additional short period if necessary. A suitable small intercostal retractor was then inserted and the intercostal space opened. The LUL could then be tucked inferiorly out of the way with a small opened gauze. A ½ inch malleable copper retractor was sometimes necessary to keep the lung retracted. The descending aorta and PDA were then visualized and palpated to confirm the presence of a thrill over the PDA as well as the pulmonary artery.

The parietal pleura over the descending aorta immediately posterior to the ductus was divided vertically, and the anterior reflection was held with a stay suture. The superior intercostal vein was clipped and divided if necessary. The ductus was carefully dissected free with the use of blunt-tipped right-angled forceps or scissors. A 20-mm Ligaclip (Ligaclip, Applied Medical Resources, Rancho Santa Margarita, CA) was placed through the pericardium and the ductus arteriosus was occluded. The ductus was then divided with a scissors. The Ligaclip was then opened and the ductus arteriosus was reinserted into the aorta and pulmonary artery. The Ligaclip was then closed and the ductus arteriosus was confirmed to be occluded. The gauze in the LUL was removed and the LUL was inspected for collapse; the gauze was then reinserted for an additional short period if necessary. A suitable small intercostal retractor was then inserted and the intercostal space opened.

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1512

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Figure 1. Minithoracotomy wound.

PDA = patent ductus arteriosus
Dennis-Brown dissecting forceps. Sodium nitroprusside was used to provide controlled hypotension and after test clamping the ductus to determine that the patient was not duct-dependent, the ductus was clipped with a large Ligaclip under controlled hypotension at a systolic pressure of 70 mm Hg (Fig 2). The pulmonary artery was palpated to confirm that the thrill was no longer present. The pleura was closed over the ductus and aorta and the chest closed over a single fenestrated drain. In the event of a tear in the ductus, the surgeon would gain digital control over the ductus while the assistant extended the thoracotomy anteriorly. The ductus would then be divided and sutured. Patients were monitored overnight in the cardiac ICU before being transferred to a ward.

RESULTS

Collapse of the LUL was readily accomplished in all cases with this technique of gentle compression and took no more than 5 min in all cases. No intraoperative hypoxia was detected on oximetry or analysis of blood gas levels. All operations were completed in less than 1 h, with the majority taking less than 45 min. Chest drains were removed the following morning, and in all cases the total drainage was less than 50 ml, with no drainage in six cases. No residual atelectasis was detected clinically or radiologically. Analgesic requirements were minimal, and all patients were rapidly mobilized. Full mobility of the shoulder was regained by the following day. All 11 patients were reviewed 4 to 11 months postoperatively, and no residual murmurs were detected.

DISCUSSION

Closure of the PDA was successfully accomplished in these children and adolescents with the minithoracotomy technique, induced LUL atelectasis, and clipping of the PDA. The provision of visibility and access through LUL atelectasis was the key step which facilitated the performance of the procedure through a minithoracotomy. The technique of inducing LUL collapse by gentle compression was simple and effective, and in these patients, it did not appear to cause intraoperative hypoxia or postoperative residual atelectasis. The location of the minithoracotomy incision over the second interspace in the midaxillary region also aided the approach, by allowing the PDA to be seen directly beneath the incision once the LUL was collapsed. For this incision to be used, the patient had to be positioned with the left side uppermost and with the arm abducted above the head. In this position, the headlight and operating lamp provided adequate lighting. Closure of the ductus with a Ligaclip was a very simple maneuver which could be performed with very little prior dissection, and as such, this procedure was very suitable for and readily performed through the minithoracotomy.

Apart from blunt-tipped right-angled artery forceps and Dennis-Brown dissecting forceps, no special instruments were required, although some experience with ductal ligations through a lateral thoracotomy is useful. Some mention of the design of the Ligaclip and its applicator is relevant here to highlight the precautions taken to prevent damage to the ductus arteriosus. Since the tips of the Ligaclip have a roughened surface, they were kept well away from the walls of the ductus when the clip was being applied. In addition, since the applicator is designed to approximate the tips of the Ligaclip more closely than the body, care was taken to ensure that the tips were positioned beyond the edge of the ductus at the time of Ligaclip closure. Further, in order to minimize the risk of crushing or cutting through the ductus, the Ligaclip was closed under controlled hypotension. However, with further experience gained with this technique, controlled hypotension with sodium nitroprusside and arterial monitoring lines may not prove to be essential in the future. Although in these patients hemorrhage was not a problem, as a precaution the assistants and nursing staff were well briefed on the procedure to be used in the event of hemorrhage.

The morbidity associated with this procedure appeared to be minimal. Compared to a lateral or posterolateral thoracotomy, a minithoracotomy wound utilizes a much smaller skin wound and involves far less muscle division. In this minithoracotomy the intercostal muscles were divided for a short distance, whereas when a lateral or posterolateral thoracotomy is performed the serratus anterior, latissimus dorsi, and the intercostal muscles are divided for some length. In addition, there is less distraction of the ribs with less stretching of ligaments and joints compared with that in a thoracotomy. Blood loss also was minimal, and movements of the upper limb rapidly returned to normal in the postoperative period.
Although this procedure readily could be adapted for use through a thoracoscope, there are some inherent advantages to using a minithoracotomy. In particular, there is no loss of stereoscopic vision, and no special apparatus or expertise is required. In the abdomen, gas insufflation is necessary to tent up the abdomen to provide working space, and visibility is provided by a laparoscope inserted through an airtight port. In the chest, because of the presence of the rigid rib cage insufflation is unnecessary, and once the lung has been collapsed, the PDA can be approached directly. A thoracoscope and airtight ports thus need not be used.

In summary, this procedure of induced atelectasis and Ligaclip closure of the PDA through a minithoracotomy is simple, requires no special instruments, and can be performed in children and adolescents with minimal morbidity.

REFERENCES
1 Gross RE, Hubbard JP. Surgical ligation of the patent ductus arteriosus: report of first successful case. JAMA 1939; 112:729-31