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Division, or ligation of patent *ductus arteriosus*?

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*Helenos: la fortuna está en no buscarla,
y habéis intentado todos los pasos del mar.*
Alfonso Reyes

ABSTRACT

Background: Surgical ductal division is the traditional and most effective treatment of the persistence of *ductus arteriosus*. New therapeutic techniques such as ductal clipping occlusion or division by means of thoracoscopic or extrapleural surgery are recommended for substitution of the traditional treatment procedure. The purpose of this paper is to analyze the state of the art of these new therapeutic procedures and to compare them with the traditional procedure. **Material and methods:** From reports in the medical literature, we analyzed the indications, results, and complications of minimal invasive ductal surgery. We compared these new techniques with the major challenge faced 35 years ago with patent *ductus arteriosus* surgical division of patients with severe pulmonary artery hypertension. **Results:** In the past, the major surgical challenge of the persistence of *ductus arteriosus* with severe pulmonary artery hypertension was successfully resolved. At present, according to our analysis, when open surgery is performed ductal division is not practical but is essential in presence of complicated cases. When experience is gained, minimal invasive surgery can be performed safely in well-selected cases. **Conclusions:** When extracorporeal circulation is unnecessary, minimal invasive surgery might take the place of traditional ductal division. However, not enough time has elapsed to evaluate the long-term results of this method.

Key words: Patent *ductus arteriosus*, patent *ductus arteriosus* surgery, thoracoscopic clipping of the patent *ductus arteriosus*, extrapleural patent *ductus arteriosus* approach.

RESUMEN

Antecedentes: El tratamiento tradicional y más efectivo de la persistencia del conducto arterial es la división quirúrgica del mismo. Su oclusión con grapas mediante toracoscopia o su división por vía extrapleural son nuevas técnicas recomendadas para substituir la terapia tradicional. El propósito del presente artículo es analizar el estado del arte de esas nuevas técnicas terapéuticas, en comparación con la terapéutica tradicional. **Material y métodos:** De los informes de la literatura médica, analizamos las indicaciones, resultados y complicaciones de la cirugía del conducto arterial persistente mediante las vías de acceso con mínima invasión. Como piedra angular de comparación hicimos referencia al mayor reto enfrentado hace 35 años por la cirugía al seccionar el conducto arterial severamente hipertenso. **Resultados:** En el pasado, fueron satisfactoriamente resueltos los mayores retos enfrentados en el tratamiento del conducto asociado a severa hipertensión arterial. Cuando es practicada la cirugía "abierta", la simple división del conducto es mucho mejor que la ligadura y esta última es imprescindible cuando no es práctica la división. Cuando el cirujano ha adquirido suficiente experiencia, la cirugía mínimamente invasiva es efectiva y segura en casos seleccionados. **Conclusión:** Cuando es innecesaria la circulación extracorpórea, la cirugía mínimamente invasiva podría substituir a la tradicional división quirúrgica del conducto. Sin embargo, no ha transcurrido suficiente tiempo para evaluar los resultados a largo plazo, de esta forma de tratamiento.

Palabras clave: Conducto arterial persistente, cirugía del conducto arterial persistente, cirugía toracoscópica del conducto arterial persistente, cirugía extrapleural del conducto arterial persistente.

INTRODUCTION

The patent *ductus arteriosus* (PDA) causes death in 50% of patients with the disease who reach 30 years of age¹ and in 61% of patients reaching > 60 years of age.² To postpone PDA surgery could increase the probability of pulmonary arterial hypertension,³ calcification, heart failure, and endarteritis in patients reaching the age of 20 years. In 153 adult studied by one

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of us (CZ) at the National Institute of Cardiology Ignacio Chávez, 33 patients had complications of pulmonary arterial hypertension (mean pressure 111 mm Hg), 32 calcification, six heart failure, and six endarteritis.⁴

“Diagnosed PDA, operated PDA” is the gold standard. Since the early reports of PDA surgery, there has been a constant debate regarding optimal management of PDA: division vs ligation. This debate has been renewed and has increased with the advent of new therapeutic techniques such as thoracoscopic interruption or the extrapleural approach. To date, the surgical form of treating the PDA (either division or ligation)^{5,6} remains the motive of unresolved discussion.^{5,6}

The purpose of this article is to evaluate the proposal, results, benefits, complications, and tendencies of new PDA treatment techniques compared with the older technique, PDA surgical division.

THORACOTOMY

Antecedents. Division of PDA can be accomplished at minimal risk of mortality,⁷⁻⁹ even in low-birth-weight neonates^{10,11} or even in patients (children, adolescents or adults) with pulmonary arterial hypertension. Surgeons have overcome all risks related

Table I. Data of patients with PDA associated with pulmonary artery hypertension.

N	Age (years)	P1 (mm Hg)	P2 (mm Hg)	Follow-up (months)
1	6	120	45	12.0
2	4	90	52	92.0
3	14	118	48	7.0
4	24	135	100	5.0
5	44	100	45	0.5
6	30	120	62	0.5
7	5	92	38	7.0
8	7	93	50	0.0
9	31	122	132	7.0
10	34	95	40	14.0
11	9	90	42	24.0
12	22	80	40	0.0
13	4	110	50	7.0
\bar{X}	18.0	105.0	57.2	13.5
S	13.6	16.7	27.6	24.5
R	4-44	80-135	38-132	0-92

P1 and P2 = Pulmonary artery pressure before (P1) and after (P2) PDA surgical division. Follow-up = months elapsed from post-operative catheterization. \bar{X} = mean, S = standard deviation, R = range.

to surgical treatment of PDA. Blood loss is minimal (10 to 15 mL), damage of the left recurrent laryngeal nerve is avoidable, morbidity and post-operative pain is minimal, and calcified or friable PDA can be managed by means of cardiopulmonary by-pass. Generally, surgical treatment of PDA is performed rapidly and safely without cardiopulmonary by-pass, and the patient is able to walk the day after surgery and is discharged from the hospital 2 days post-surgery. Thirty-five years ago, the challenge in PDA surgery was the case of the patient with severe pulmonary artery hypertension. In *table I* we listed data of 13 patients with PDA and pulmonary artery hypertension operated on 35 years ago,¹² when surgery was not recommended for these patients. Box-graphics of *figure 1* show a relevant decrease in pulmonary artery pressure after PDA division. Quijano-Pitman confirmed these results.¹³

Division vs ligation. The difference between section and ligation of PDA is that the former is 100% curative, while the second is, in some cases, incomplete and of course a palliative method because it frequently gives rise to PDA reopening and reoperation. To avoid post-operative ductal recanalization, PDA section is soundly recommended instead of ligation. The debate of PDA ligation vs PDA division was resolved when Shapiro and Johnson in 1947 confirmed that division of PDA was the optimal surgical management of PDA (*Op. Cit.* Ambalavanan).⁶ These authors showed that PDA ligation was obsolete and should be employed only when division

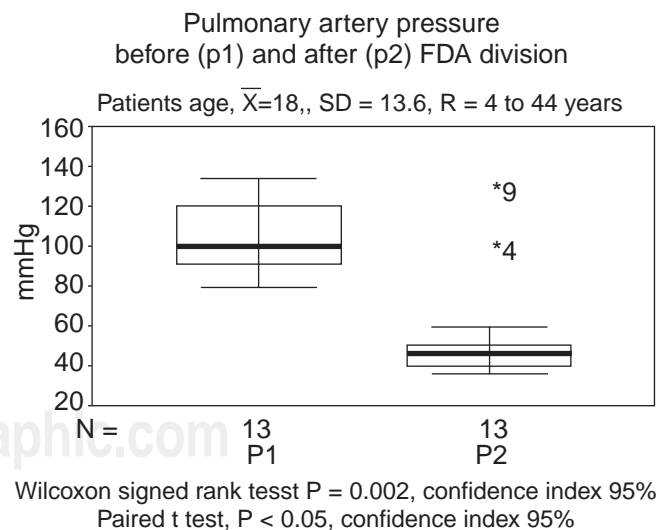


Figure 1. Box-graphics representing changes in pulmonary artery pressure before (P1) and after (P2) PDA surgical division.

was not practical. Pérez-Redondo and Limón confirmed that division of PDA was the optimal surgical management.¹² It has been observed that after PDA ligation, 19.7% of patients presented either recanalization or incomplete closure.¹⁴ Aneurysm of PDA is among the complications of surgical PDA ligation.¹⁵ In some cases, false aneurysm occurred after recanalization of PDA.^{14,16} Even with double or triple ligation, 22% of patients had residual PDA and required division of PDA. According to Ambalavanan, surgical PDA ligation is recommended only when division is not practical, such as with a short or friable PDA or in premature infants in whom division is technically difficult.⁶ Because ductal recanalization occurs in 6 to 23% of patients, to perform PDA division instead of PDA ligation is sound advice.¹⁷

Current challenges. Although surgical PDA closure is a safe and successful procedure in premature¹⁸ and low-body-weight infants, the risk of sepsis, respiratory distress syndrome, and a long post-operative intubation period^{18,19} could make PDA intraluminal closure preferable in these children.²⁰ The presence of PDA in premature infants with respiratory distress syndrome is a challenge. According to Mikhail and colleagues, surgical PDA ligation in these patients is associated with zero surgical risk, reduced incidence of respiratory distress syndrome, and improvement in patient long survival.¹¹ Nevertheless, because of the condition of prematurity, post-operative morbidity and mortality of surgical PDA ligation are higher in premature infants than in older children.¹⁰ Some cases of PDA are still a challenge to open surgery because of possible rupture of the PDA or the aorta, i.e., cases of false or mycotic aneurysms,²¹ calcified PDAs, endarteritis, and severe pulmonary arterial hypertension. However, good results have been obtained with the surgical approach in different situations of complicated PDAs.²²

MINIMAL INVASIVE SURGERY

A great number of patients has been operated on with thoracoscopic or extrapleural procedures with good immediate results. According to their promoters, these new techniques are safe, less traumatic, and have better cosmetic effects.²³

Transaxillary thoracotomy. Vertical incision thoracotomy sparing *pectoralis* major muscle and *latissimus dorsi* muscle for closure of PDA and without thoracostomy tube provides good exposure of the duct and improved functional and cosmetic results as well

as less postoperative pain²⁴⁻²⁶ It has been reported that this surgical method has similar cost, higher efficacy rate, and applicability in all patients compared with transcatheter coil occlusion techniques²⁷

Video-assisted thoracoscopy. Despite the low rate of complications (bleeding, air leak, cardiac arrhythmias, empyema, pneumothorax) of video-assisted thoracoscopic surgery of PDA,^{28,29} some authors consider that has a potential risk of uncontrolled exanguinating hemorrhage.³⁰

Minimal invasive surgery with division vs ligation. Patent *ductus arteriosus* ligation could give rise to incomplete ductal closure,³¹ recanalization, and reoperation in some patients. Recanalization of PDA might occur 3, 17, or 19 years after PDA thoracoscopic ligation, such as in cases of surgical PDA ligation.³² Section and suture or two-clip occlusion is a guarantee of 100% interruption of PDA and avoids the question of ductal recanalization. Closure of the PDA with ligaclip or with metallic clips could avoid or reduce the probability of ductal recanalization and render PDA ligation through minithoracotomy safe from PDA recanalization.³³ Ligation of PDA by thoracoscopic surgery could be difficult due to the presence of pleural fibrosis in the patient.²⁸ Insufficient dissection resulting in inadequate PDA ligation is observed when surgeons initiate their first experience with video-assisted thoracoscopic PDA surgery.³¹

CONCLUSIONS

When extracorporeal circulation is unnecessary, thoracoscopic or extrapleural surgery might take the place of traditional ductal division. However, not enough time has elapsed to evaluate the long-term results of this method. On the other hand, in some cases minimal ductal surgery is contraindicated, such as with ductal mycotic aneurysm, severe pulmonary artery hypertension, ductal extreme dilation, etc. To date, open surgery can confront all these situations. Thoracotomy for PDA ligation and division appears to be the safest, most effective and widely applicative therapeutic procedure.

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