The outcome of the vertical vein left intact during the surgery for total anomalous venous connection and its effects on ventricular functions

Total anormal pulmoner venöz bağlantı nedeniyle yapılan ameliyatta açık bırakılan vertikal venin akıbeti ve ventrikül fonksiyonlarına etkisi

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ABSTRACT

Objective: We examined the fate of intact vertical vein during long-term follow-up and its effects on ventricular functions.
Methods: Eighty one patients with all types of total anomalous pulmonary venous connection (TAPVC) were operated. Thirty-one patients with supracardiac type TAPVC were examined in our retrospective cohort study. Groups were evaluated with respect to left ventricle area, volume, end-systolic, end diastolic diameter, early and late term mortality and properties of pulmonary hypertensive crisis. Vertical vein was left open in 14 patients and it was ligated in 17 patients. Wilcoxon rank and Mann- Whitney U tests were used to compare variables between groups.
Results: After mean follow up of 48±36 months, vertical vein closed spontaneously in 3 patients. Two of them were closed surgically due to elevated shunt flow and there was spontaneous closure in one patient who had the highest pulmonary artery pressure amongst others postoperatively. Preoperative left ventricular area, volume, end-systolic diameter and end-diastolic diameter values of the patients increased from 3.5± 0.9 mm^2-2.9±0.9 mm^3-14±5 mm-8±4.5 mm to 8±3.3 mm^2 -16±8.7 mm^3-27±6.7 mm-17±4.8 mm at the postoperative period in Group 1, and from 6.8±3.5mm^2-8.4±8.7 mm^3-15±6.4 mm-9±5.3 mm to 7.4±5.2 mm2-16±1.7 mm^3-21.7±5 mm-13.5±4.1 mm in Group 2, respectively (p=0.02, p=0.039, p=0.054, and p=0.07, respectively).
Conclusion: Vertical vein remains intact in most of the patients and may be closed spontaneously in patients with elevated pulmonary resistance. Intact vertical vein both decompresses the left ventricular cavity in patients with decreased left ventricular compliance until the ventricular muscle adapts to new workload and improves ventricular functions on long term follow up. Therefore, we conclude that vertical vein should be left open in selected patients. *(Anadolu Kardiyol Derg 2011; 11: 638-42)*
Key words: Pulmonary vein/surgery, cardiac surgical procedures, ventricular function

ÖZET

Amaç: Açık bırakılan vertikal venin uzun dönem takiplerde kapanıp kapanmadığını ve kapanmayan vertikal venin ventrikül fonksiyonlarına etkisini belirlemek.
Yöntemler: Toplam 81 hasta total anomal pulmoner ven dönüşü (TAPVD) tanısı ile (kardiyak, suprakardiyak, mikst ve infrakardiyak) opere edildi. Geriye yönelik kohort çalışmamızda suprakardiyak TAPVD tanısı ile ameliyat edilen 31 hasta incelenmiştir. Hastaların sol ventrikül alan, hacim, sistol ve diastol sonu çapları ile erken ve geç dönem mortalite ve pulmoner hipertansif kriz özellikleri karşılaştırılmıştır. Vertikal ven 14 hastada açık bırakılmış, 17 hastada ise kapatılmıştır. Gruplarda değişkenler Wilxocon rank ve Mann-Whitney U testleri ile karşılaştırıldı.
Bulgular: Ortalama 48±36 aylık takiplerde açık bırakılan 3 hastada vertikal ven kapanmıştır. Kapanma; fazla miktarda sol-sağ şant oluşturması sebebi ile 2 hastada cerrahi olarak yapılmıştır. Diğer hastada ise kapanma spontan olmuştur. Vertikal veni açık bırakılan grupta ameliyat öncesi ve sonrası sol ventrikül alan, hacim, diyastol sonu ve sistol sonu çapları 3.5±0.9 mm^2-2.9±0.9 mm^3 -14±5 mm - 8±4.5 mm'den sırası ile 8±3.3 mm^2-16±8.7 mm^3 - 27±6.7 mm - 17±4.8 mm'e yükselmiştir. Aynı değerler diğer grup için 6.8±3.5 mm^2 - 8.4±8.7 mm^3 - 15±6.4 mm - 9±5.3 mm ve 7.4±5.2 mm^2- 16±1.7 mm^3- 21.7±5 mm- 13.5±4.1 mm olarak hesaplanmıştır (sırası ile p=0.02, p=0.039, p=0.054, p=0.07).
Sonuç: Vertikal ven uzun süre açık kalmakta ve belki de pulmoner yatak basıncı yüksek olan hastalarda spontan olarak kapanabilmektedir. Özellikle sol kalp boşluklarının kompliyansı bozuk olan hastalarda açık bırakılan vertikal ven, hem sol ventrikül yeni hemodinamiye adapte oluncaya kadar bir dekompresyon vazifesi görmekte hem de uzun dönemde sol ventrikül fonksiyonlarına olumlu yönde katkı sağlamaktadır. Bu nedenle seçilmiş hastalarda vertikal ven açık bırakılmalıdır. *(Anadolu Kardiyol Derg 2011; 11: 638-42)*
Anahtar kelimeler: Pulmoner ven/cerrahi, kardiyak cerrahi teknik, ventrikül fonksiyonu

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Introduction

Management of vertical vein remains a challenge during surgery of total anomalous pulmonary venous connection (TAPVC). Some authors recommend its ligation intraoperatively to prevent volume overload from right to left shunting but it is controversial to close it routinely (1, 2). In fact, incidents of hepatic ischemia following surgery of infracardiac type TAPVC necessitates to leave it open in such group of patients (3). In a previous study conducted in our institution, we stated that vertical vein should be left intact to achieve better hemodynamics in patients with obstructive type TAPVC (4). However, there is little information about the fate of the vertical vein that is left open in the initial corrective surgery. It has been claimed that the vertical vein closes spontaneously in cases of infradiaphragmatic type TAPVC as a result of elevated hepatic parenchymal pressure (5). There are also some studies indicating pronounced left to right cardiac shunt (6). We have previously conducted a study in 2008 at Başkent University, Department of Cardiovascular Surgery about obstructive type TAPVC and concluded that vertical vein should be left open.

In this study; we examined the difference between early postoperative results between 2 groups, fate of the vertical vein that was intentionally left open during corrective surgery, the effect of intact vertical vein on ventricular functions and mortality. Thus, we assumed that information we obtain could facilitated the decision about vertical vein ligation or not.

Methods

Patients and study design

Preoperative, intraoperative and postoperative findings of 31 of 81 patients with supracardiac TAPVC who were operated between 1996 and 2010 were analyzed in our retrospective cohort study. Groups were evaluated with respect to ventricular functions, left ventricle area, volume, end-systolic, end diastolic diameter, early and late term mortality and properties of pulmonary hypertensive crisis. Early mortality was defined as the mortality in the first month after the operation. The mortality after first month was defined late mortality. All patients had a common venous sac opening to innominate vein through the vertical vein. There were 14 patients (Group 1) whose vertical veins were left intact (45.1%) and 17 patients (Group 2) who had their vertical veins ligated during surgery (54.8%). Decisions to leave the vertical vein open were made preoperatively in two patients due to relatively small size of left cardiac chambers; on the other hand, decisions were made according to intraoperative measurements for the other 12 patients. Vertical vein was occluded temporarily after cardiopulmonary bypass and left atrium (LA), pulmonary artery (PA) and aorta (Ao) pressures were recorded. If there was increase in PA and LA pressures with low Ao pressure values then the vertical vein was left open. There was only one patient who needed an interatrial shunt additionally since he suffered from low cardiac output although vertical vein was open.

Operative technique

Cardiopulmonary bypass was conducted with standard aortic and bicaval cannulation. Single dose cold crystalloid cardioplegia was used for diastolic arrest. For the patient with normal situs, the heart was retracted out of the left chest toward the patient's right shoulder. An incision was made in the anterior surface of the common pulmonary vein in the posterior pericardium. A mirror counter incision was made in the posterior aspect of the left atrial appendage. An anastomosis was created between the orifice in the posterior aspect of the left atrium and the common pulmonary vein. Deep hypothermic circulatory arrest was needed for 24 patients initially for couple of minutes. These 24 patients had rectal temperature values of 18-20°C, whereas the rest of the patients were cooled down to 26-28°C. Atrial septal defect was closed with autologous pericardial patch.

Statistical analysis

Analysis was done with SPSS (Statistical Package for the Social Sciences for Windows, version 11.0, SPSS Inc, Chicago, IL, USA). Wilxocon rank, Mann-Whitney U and Chi-square tests were used to compare variables between groups. A $p<0.05$ value was defined as statistically significant.

Results

Demographic, echocardiographic and angiographic properties

Patient demographics are summarized in Table 1. Patients in Group 1 had lower body weight and were operated at a younger age ($p\leq0.05$). There were obstructive type connection in 10 patients and vertical vein was left open in nine of them. Mean pulmonary arterial pressure values were higher in Group 1 ($p\leq0.05$). Although end-diastolic and end-systolic diameter values of left ventricle were smaller in Group 1, there were no statistical differences between two groups. However, there were statistical difference between two groups in terms of left ventricle cavity area and volume, which were lower in Group 1 ($p\leq0.05$) (Table 2). There were no differences between two groups preoperatively regarding need for mechanic ventilation, positive inotrope support or urgent operation. Cardiopulmonary bypass (CPB) and aortic clamp times were 92.7±24 and 47±15 minutes for Group 1 and 85±27 and 44±10 minutes for Group 2.

Neither postoperative intubation times nor intensive care unit stay periods were different between two groups (Table 1). Early mortality was 7.1% (n=1) for Group 1 and 17.6% (n=3) in Group 2. Mortality in Group 1 was due to low cardiac output whereas 3 mortalities in Group 2 resulted from pulmonary hypertensive crisis (Table 3). On the other hand, rate of pulmonary hypertensive crisis was apparently higher in Group 1 ($p<0.05$). After mean follow-up of 49±31 months, survival rate was 84.6% with 2 mortalities due to sudden death in Group 1 while, there was only one mortality in Group 2 due to low cardiac output during long term follow-up.

Follow-up

The mean follow-up time was 48±36 months. Vertical veins in 2 patients of Group 1 were closed surgically and in 1 patient with high PA pressure and vascular resistance, it closed spontaneously. Table 2 shows the changes in left and right ventricular volume, area and diameter values. According to these findings, left ventricular area and volume values were apparently lower in Group 2. Nonetheless, increases in these values were also significant in Group 1 at the end of follow-up.

Table 1. Patient demographics

Variables	Group 1	Group 2	p*
Number of patients , n	14	17	
Age, months	3.8 ±2.1	4.6±4.4	0.011
Weight, kg	4.4±1.1	6.8±5.9	0.035
Obstructive TAPVC, n	9	1	0.01
SPAP, mm-Hg	47±14	33±10	0.04
MPAP, mm-Hg	32±11	24±9	0.03
DPAP, mm-Hg	20±9	13±3	0.01
LVA, mm^2	3.5±0.9	6.3±3.5	0.04
LVV, mm^3	2.9±0.9	8.4±8.7	0.01
LVEDD, mm	14.0±5.8	15.0±6.4	0.39
LVESD, mm	8.0±4.5	9.0±5.3	0.36
Preoperative intubation, n	3	1	0.42
Urgent surgery, n	1	0	0.96
PHC, n			
Yes	10	2	0.04
No	4	15	0.03
CPB, min	92.7±24.0	85.0±27.0	0.19
ACT, min	47±15	44±10	0.29
Postop. intubation time, hours	24±11	36±27	0.06
ICU stay, days	3.0±4.1	4.0±3.3	0.7
Postop. inotropic support, n	12	11	0.9

Data are presented as mean±SD and proportions
*Mann-Whitney U and Chi-square tests
ACT - aortic clamp time, CPB - cardiopulmonary bypass, DPAP - diastolic pulmonary artery pressure, LVA - left ventricular area, LVEDD - left ventricular end-diastolic diameter, LVESD - left ventricular end-systolic diameter, LVV - left ventricular volume, MPAP - mean pulmonary artery pressure, PHC - pulmonary hypertensive crisis, SPAP - systolic pulmonary artery pressure

Discussion

In the present study, it is speculated that, the vertical vein which is left open can be closed spontaneously and at the end of the long-term follow-up, it can be contributed the ventricular growing.

One of the issues recently raised in the surgical literature is whether or not the vertical vein should be ligated at the time of total anomalous pulmonary venous repair. Chowdhury et al. (7) recommended the use of an adjustable ligature around the vertical vein. On the other hand, in the study reported by Kelle et al. (8) the vertical vein was ligated in all patients and postoperative pulmonary hypertension was managed by nitric oxide therapy and conventional ventilator management strategies.

In spite of the advances in surgical techniques and critical care protocols, poor compliance of left ventricle and atrium is the major cause for mortality and morbidity following TAPVC surgery (9, 10). This is especially important in patients with obstructive type TAPVC anomaly (11, 12). Intact vertical vein acts as a reservoir during the time needed for left heart chambers to adapt themselves to the newly constructed hemodynamics (7, 13). In both of our studies, preoperative mean PA pressure values were significantly higher, whereas on the contrary, left ventricular area and volume values were lower in Group 1. This can be explained with the fact that majority of the patients in Group 1 had obstructive type anomalies ($p<0.05$), because presence of pulmonary venous hypertension causes increased right ventricle afterload, shifting of the septum towards left ventricle and finally underdeveloped left ventricular cavity (14, 15). Mean age of patients at the time operation was also lower in Group 1, which may be another factor causing difference in sizes of the cardiac chambers between two groups.

Table 2. Effect of the intact vertical vein on left ventricular functions postoperatively

Variables	Group 1		Group 2				
	preop	postop	preop	postop	p1*	p2**	p3**
RVA, mm^2	10.7±5.5	9.1±3.0	11.9±6.0	8.8±5.0	0.06	0.07	0.06
RVV, mm^3	16.4±8.7	15.7±8.0	23±18	15±14	0.04	0.06	0.06
LVA, mm^2	3.5±0.9	8.0±3.3	6.8±3.5	7.4±5.2	0.02	0.02	0.07
LVV, mm^3	2.9±0.9	16.0±8.7	8.4±8.7	16±1.7	0.039	0.01	0.06
LVEDD, mm	14±5	27.0±6.7	15.0±6.4	21.7±5	0.054	0.04	0.053
LVESD, mm	8.0±4.5	17.0±4.8	9.0±5.3	13.5±4.1	0.07	0.03	0.06

Data are presented as mean±SD and proportions
*Mann-Whitney U test: p1 - Group 1 vs Group 2
**Wilxocon rank test: p2 -preop. vs postop. in Group 1, p3 - preop. vs postop. Group 2
LVA - left ventricular area, LVEDD - left ventricular end-diastolic diameter, LVESD - left ventricular end-systolic diameter, LVV - left ventricular volume, RVA - right ventricular area, RVV - right ventricular volume

Table 3. Mortality and its causes

Variables	Group 1	Group 2
Mortality, n	1	3
Mortality cause, n		
PHC	0	3
Arrhythmia	0	0
Sepsis	0	0
LCOS	1	0

Data are presented as proportions
LCOS - low cardiac output syndrome, PHC - pulmonary hypertensive crisis

According to data from current literature, preoperative need for mechanical ventilation, positive inotropes and episodes of postoperative pulmonary hypertensive crisis; which is the major factor for mortality; are more common among patients with obstructive type TAPVC (16). This has been the same for our patients, but none of our patients from Group 1 died of pulmonary hypertension, although rate of PA hypertensive crisis was higher in this group. However, 3 cases of mortality in Group 2 were linked to pulmonary hypertensive crisis. Therefore, we think that flow through the intact vertical vein decompresses the right heart during periods of pulmonary hypertensive crisis in patients of Group 1.

Generally, maintaining high partial oxygen saturation values lowers the risk for pulmonary hypertensive crisis by causing pulmonary vasodilatation. Highly saturated blood flowing through vertical vein and reaching the pulmonary circulation is expected to lower the risk of pulmonary hypertensive crisis, but this has been the opposite in our series. This may be so because these patients were in greater risk for pulmonary hypertensive crisis.

In our study, there was no difference in CPB and aortic clamp times between two groups. However, it is known that dissection of the vertical vein extends duration of CPB (1), but on the contrary, CPB time was longer in Group 1. This may be the case because longer time is needed in patients with obstructive TAPVC to achieve stable hemodynamics following aortic declamping. Additionally, we dissected the vertical vein, in case we have to ligate it after intraoperative measurements. It should be noted that, there were no differences between times of mechanical ventilation and intensive care unit stay.

At the end of 48±36 months follow-up, minimal left-to-right shunt flow was detected through intact vertical vein. There was a pronounced shunt flow in two patients, who further underwent operation to close the vertical vein. There was a spontaneous closure in one patient who had higher pulmonary vascular resistance compared to others. This may be similar to the mechanism of closure in infradiaphragmatic type TAPVC due to high hepatic vascular resistance. On the other hand, increased left ventricular volume and area in patients with open vertical vein suggests that its presence contributes to left ventricular functions.

Study limitations

Although, in this study, the vertical vein, which was left open, has desirable effect, it is difficult to explain how vertical vein improves left ventricular functions. Even though shunt flow through vertical vein is above tricuspid valve and seems to decrease left ventricular preload, left ventricular training happens due to cumulative effect of reverse right-to-left shunt because these patients suffer pulmonary hypertensive crisis at the early postoperative period.

Conclusion

We would like to conclude that patients with obstructive type TAPVC benefit from intact vertical vein in the postoperative period since they have left heart chambers with poor compliance and higher risk for pulmonary hypertensive crisis. Shunt through the vertical vein does not cause any negative effect on hemodynamics, on the contrary contributes to left ventricle functions on the long term.

Conflict of interest: None declared.

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