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Review Article

Application and clinical value of percutaneous VSD closure guided by echocardiography alone

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Abstract: The application and clinical value of transcatheter ventricular septal defect (VSD) closure guided by echocardiography alone were explored. A total of 48 children undergoing percutaneous VSD closure guided by ultrasound were collected as a study group, and 52 children undergoing percutaneous VSD closure guided by conventional radiation were enrolled as a control group (con group). The operation time, occluder diameter, equipment cost, and total cost of the study group were lower than those of the con group, and the NT proBNP level in the two groups reached the peak 24 h after treatment and began to decrease 48 h later, and the water level of NT proBNP in the study group was lower than that in the con group. Additionally, there was no significant difference in serum CK-MB between the two groups before and after treatment, and the serum cTnI level in the study group was lower than that in the con group. The IL-10 level in the two groups increased after treatment, and the level in the study group was significantly higher than that in the con group. Moreover, both groups showed improved heart function indexes, and there was no significant difference in cardiac function and the total incidence of postoperative complications between the two groups. VSD diameter, occluder diameter, superior margin to aortic valve, and operation time were independent risk factors for complications of VSD patients. Percutaneous VSD closure guided by echocardiography alone can significantly improve the cardiac function and alleviate myocardial injury, which has good clinical value. The size of VSD, diameter of occluder, distance between the upper edge and aortic valve, and operation time are all factors that affect the postoperative complications.

Keywords: Echocardiography, radiation, transcutaneous closure of VSD, clinical value, risk factors

Introduction

Ventricular septal defect (VSD), which occurs in all ages, is a prevalent congenital heart disease, accounting for appropriate 40% of congenital heart disease [1]. VSD is mainly formed due to the abnormal development of ventricular septum during the embryonic period, resulting in the abnormal traffic between the ventricles, which mainly occurs in the membranous septum and muscular septum or its boundary [3]. At present, there are many studies on different treatments for VSD closure. Conventional open heart surgery is the traditional treatment for patients with VSD, which can solve many kinds of deformities. However, because the open chest surgery is to repair VSD directly under the assistance of cardiopulmonary bypass, the trauma is relatively large, which may bring about serious mental and physical injury [4]. Since the first application of transcutaneous VSD closure in 1988, with the continuous development of medical closure devices and deployment technologies, transcutaneous VSD closure has been widely applied in many institutions around the world [5-7]. Percutaneous VSD closure does not require thoracotomy and cardiopulmonary bypass, but it may cause radiation damage to patients and doctors due to the use of radiation, and the use of contrast agents may cause renal failure and allergy [8]. However, ultrasound-guided percutaneous VSD closure overcomes these shortcomings, which has the characteristics of no incision, avoiding the use of radiation, minimally invasive, and no need of cardiopulmonary bypass [9, 10]. NT proBNP is one of the biomarkers of cardiovascular disease [11], and it can be used as an assistant marker for comprehensive diagnosis, screening, management and follow-up of heart failure caused by various congenital and acquired heart diseases [12]. Studies have shown that mechanical stimulation of ventricular wall and pressure changes can affect the synthesis and release of NT ProBNP in cardiomyocytes [13]. Creatine kinase isoenzyme (CK-MB) is a common clinical myocardial enzyme spectrum, which mainly exists in the cytoplasm of myocardial cells. When myocardial cells are damaged, the activity of CK-MB increases significantly. With high sensitivity and rapid change, CK-MB can be used as a biochemical marker in serum after myocardial injury [14, 15]. CTnI is an inhibitory subunit, which belongs to the troponin complex (TN), and is an inhibitor of ATPase in the transverse bridge of myocardial fiber. It can participate in the down regulation of the relaxation and contraction of myocardial fiber in Ca^{2+} together with other subunits in TN complex. The expression of cTnI is related to the severity of myocardial injury and can be used as a marker of myocardial injury [16, 17]. Interleukin-10 (IL-10) is one of the anti-inflammatory factors, which can inhibit the migration and activation of inflammatory cells, and can inhibit a variety of nuclear transcription factors [18]. Some studies have verified the importance of IL-10 in the pathogenesis of experimental myocarditis [19]. However, the clinical value of percutaneous VSD closure guided by echocardiography alone and its influence on NT proBNP, CK-MB, cTnI and IL-10 need further exploration.

The study aimed to explore the clinical significance of percutaneous VSD closure under the guidance of echocardiography and the influencing factors of complications by comparing the effect and complications of percutaneous VSD closure under the guidance of echocardiography and traditional radiation.

Method

General information

A total of 48 patients undergoing percutaneous VSD closure guided by ultrasound were selected as the study group, including 27 males and 21 females, with an average age of 12.56±5.11 years, average weight of 31.78±10.12 kg, and VSD diameter 4.76±0.81 mm. A total of 52 children undergoing percutaneous closure guided by conventional radiation were selected as the control group (con group), including 30 males and 22 females, with a mean age of 13.62±5.09 years, a mean weight of 32.06±10.87 kg, and a VSD diameter of 5.03±0.96 mm.

This study was approved by the Medical Ethics Committee of Affiliated Children's Hospital of Xi'an Jiaotong University and met the standard set in the Declaration of Helsinki. All family members signed the informed consents after understanding the study.

Inclusion criteria: Patients with complete clinical data, patients with good compliance, patients whose age of VSD was more than 3 years, and the diameter of VSD was 3-10 mm, and those without pulmonary hypertension or other cardiac malformations.

Exclusion criteria: Patients with infective endocarditis, patients with cardiac malformations that require surgical treatment, patients with other infectious diseases, patients suffering from other bleeding diseases, patients with severe liver or kidney dysfunction, and those intolerable to operation.

Treatment plan

Study Group: All children were examined by echocardiography before operation, and the VSD was measured and its location was determined. The right femoral artery of the patient was punctured in supine position after anesthesia, and then catheter and guide wire were inserted. Under the guidance of echocardiography, the guide wire and catheter were sent to the ascending aorta and then to the left ventricle. Under the guidance of echocardiography, the occluder was gently fed into the right ventricle, and then the right ventricular side umbrella disc of the occluder was released. Under the guidance of ultrasound, the right ventricular opening of VSD was pressed tightly, the transport sheath was removed, and the left ventricular side of the packer was opened. Echocardiography was used to check whether the occluder had residual shunt and was far away from the aortic valve. In case of eccentric occluder, the direction of umbrella wheel should be adjusted under the guidance of ultrasound. If the sealing effect was satisfactory, release the packer under ultrasonic monitoring, take out the delivery system, apply hemostasis bandage, and complete the operation.

Control group: Anesthesia puncture was carried out on each child, and left ventricle and ascending aorta were imaged before catheter was inserted. The morphology and size of VSD were evaluated, and then the left and right cardiac catheters were examined. Subsequently, a guide-wire track was constructed, and the occlusion process was monitored by ultrasound and fluoroscopy, during which the occluder was released through femoral vein after the shape and position of the occluder were determined to be good. After operation, the ascending aorta and left ventricle were repeatedly imaged, and reexamined through ultrasound. Both groups of children were followed up and reviewed regularly.

Serum determination

Fasting venous blood (3 ml) was sampled from each child before treatment, 6 h, 24 h, and 48 h after treatment. The blood was centrifuged at 4000 R/min for 10 min. Then the serum in the test tube was carefully sucked to obtain the serum, and the serum was stored in a refrigerator at -80°C for later analysis. The contents of NT-proBNP, CK-MB, cTnI, and IL-10 were detected through a double anti sandwich enzyme-linked immunosorbent assay (ELISA) using a mk-3 automatic enzyme-linked analyzer purchased from Shanghai Yilian medical instrument development Co., Ltd., and NT-proBNP, CK-MB, cTnI and IL-10 kits provided by Shanghai Kanglang Biotechnology Co., Ltd., with product numbers of ls-f29630, kl-e11114, kl00503 and dl-il10-hu, respectively. Standard at different concentrations (50 μl) was added into the standard hole; 10 μl sample and 40 μl diluents were added into the sample hole to be tested respectively; 50 μl distilled water was added into the blank hole (the same as other steps, but without enzyme standard reagent and sample), and 50 μl enzyme standard reagent was added into the standard hole and sample hole. The reaction hole was sealed with sealing membrane, and washed after incubation in 37°C water bath for 1 h. Substrate A and B (50 μl each) were added into each hole, and the liquid in each hole was mixed gently, and developed at 37°C for 15 min without light. Termination solution (50 μl) was added into each hole, and within 15 min, the blank hole was taken as the reference value for zero adjustment, and the OD of each hole at the 450 nm wavelength was measured. The content of NT-proBNP, CK-MB, cTnI, and IL-10 were calculated.

Outcome measures

The success rate, hospitalization time, operation time, occluder diameter, equipment cost, and total cost of the two groups were evaluated. The levels of NT proBNP, CK-MB, cTnI, and IL-10 were compared before and after treatment. The left ventricular end diastolic diameter (LVEDd), left ventricular end systolic volume (LVESV), left ventricular end diastolic volume (LVEDV), and left ventricular ejection fraction (LVEF) were analyzed. In addition, the complications of the two groups were compared and the influencing factors were explored.

Statistical analysis

Spss20.0 (IBM Corp, Armonk, NY, USA) was employed for statistical analysis, and Graphpad Prism 7 (Graphpad Software Co., Ltd., San Diego, USA) was used to draw figures of the collected data. The count data was expressed as [n (%)], and compared between groups using the Chi square test. The measurement data were expressed as the mean ± standard deviation ($\overline{x}$ ± SD), and compared between groups using the T test. Single factor analysis of variance was adopted for multi-group comparison, and LSD-t test for post test. Multivariate logistic regression was adopted for analysis on risk factors of patients with heart failure and renal insufficiency. $P < 0.05$ indicates a significant difference.

Result

Comparison of general clinical data

The general clinical data of the two groups were analyzed (**Table 1**). There was no significant difference between the two groups with regard to sex, average age, average weight, VSD diameter, right ventricular end diastolic diameter, left ventricular end diastolic diameter, left ventricular ejection fraction, blood creatinine and leukocyte (all $P > 0.05$).

Comparison of operation conditions between the two groups

The operation conditions of the two groups were compared (**Table 2**). In the study group, 2

Table 1. Comparison of general clinical data between the two groups ($\overline{x}$ ± SD)/n [%]

	Study group (n = 48)	Con group (n = 52)	X^2/t	P
Sex			0.02	0.88
Male	27 (56.25)	30 (57.69)		
Female	21 (43.75)	22 (42.31)		
Average age (years)	12.56±5.11	13.62±5.09	1.04	0.30
Average weight (kg)	31.78±10.12	32.06±10.87	0.13	0.89
VSD diameter (mm)	4.76±0.81	5.03±0.96	1.51	0.13
Hemoglobin (g/L)	130.91±10.23	131.26±9.98	0.17	0.86
Platelet (× 10^9/L)	170.24±23.18	171.13±21.73	0.20	0.84
Blood creatinine (umol/L)	29.35±15.65	30.97±14.36	0.54	0.59
Leukocytes (× 10^9/L)	8.57±2.43	7.85±2.65	1.41	0.16
Platelet aggregation function (mm)	64.27±5.56	65.09±5.38	0.75	0.46

Table 2. Comparison of basic operation conditions between the two groups ($\overline{x}$ ± SD)/n [%]

	Study group (n = 48)	Con group (n = 52)	X^2/t	P
Success rate of operation	45 (93.75%)	49 (94.23%)	0.01	0.92
Operation time (min)	41.23±12.32	53.82±12.11	5.15	< 0.05
Length of stay (d)	3.76±0.77	3.69±0.78	0.45	0.65
Intraoperative application of radiation	0	100%	-	-
Occluder diameter (mm)	6.22±2.13	6.98±1.63	0.55	0.04
Equipment cost (10000 yuan)	2.23±0.45	2.87±0.83	4.74	< 0.05
Total cost (10000 yuan)	3.45±0.75	4.61±0.91	6.92	< 0.05

cases were converted to transthoracic VSD, because the catheter failed to pass through VSD along the guide wire. Because the residual shunt was more than 2 mm in one child, it was repaired by surgery. In the con group, 1 patient had unstable occluder, 2 patients could not establish the orbit successfully, and all patients changed to conventional surgical repair. There was no significant difference between the study group and the con group in the success rate of operation and the length of stay ($P > 0.05$). The operation time, occluder diameter, equipment cost and total cost of the study group were statistically lower than those of the con group ($P < 0.05$).

Comparison of serum factor levels between the two groups before and after treatment

There was no significant difference in the levels of NT proBNP, CK-MB, cTnI and IL-10 between the two groups before treatment ($P > 0.05$). After treatment, no significant change was found in serum CK-MB in the two groups ($P > 0.05$), and there was no remarkable difference between the two groups ($P > 0.05$). After treatment, the NT proBNP level in serum was significantly higher than that before treatment, and the highest level of NT proBNP was seen 24 h after treatment, and it began to decrease 48 h later. The water level of NT proBNP in the study group was lower than that in the con group at each time point after treatment ($P < 0.05$). The level of serum cTnI in the study group was lower than that in the con group ($P < 0.05$). The level of IL-10 in the two groups was greatly higher than that before treatment ($P < 0.05$). The peak was reached at 6 h after treatment, and it was greatly higher in the study group than in the con group ($P < 0.05$). There was no remarkable difference between the two groups at 24 h and 48 h after treatment ($P > 0.05$) (**Figure 1**; **Table 3**).

Changes of cardiac function in the two groups before and after treatment

The changes of cardiac function indexes before and after treatment were shown in **Table 4**. There was no remarkable difference between the two groups ($P > 0.05$). After treatment, LVEDd, LVEDV, LVESV and LVEF in the two

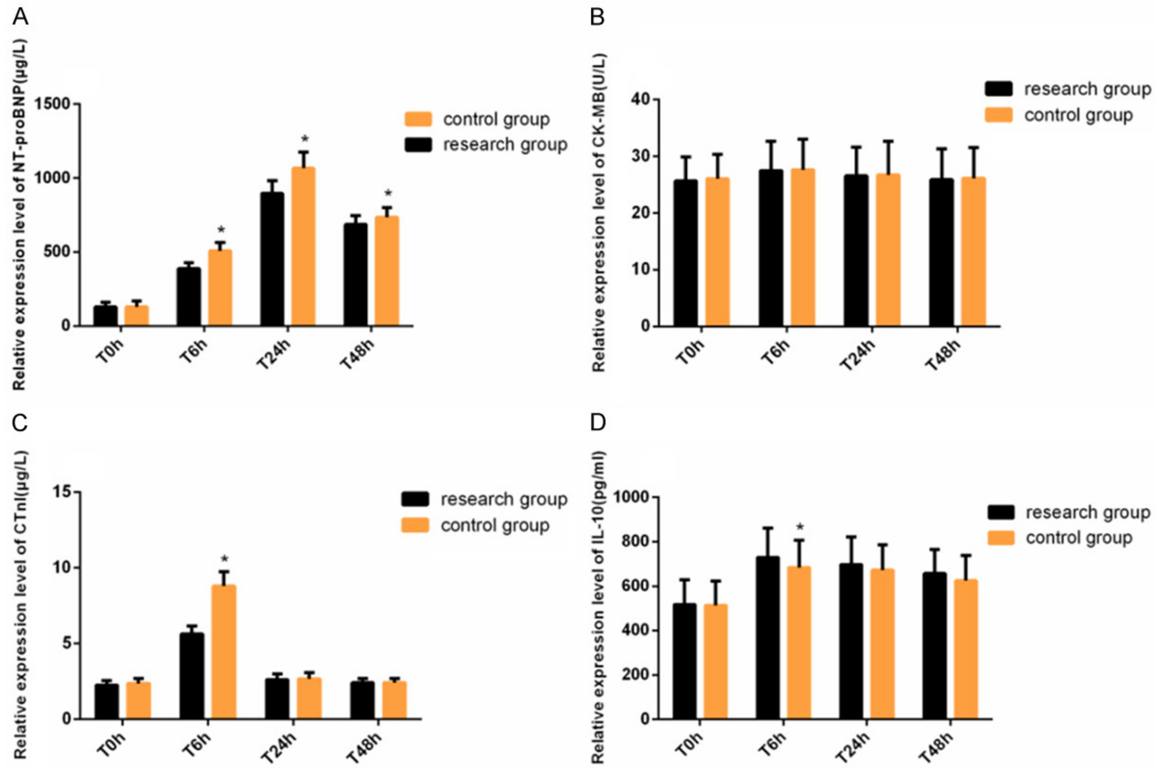

Figure 1. Comparison of serum factor levels before and after treatment. A. The level of NT proBNP in the two groups reached the peak 24 h after treatment, and began to decrease 48 h later, and the water level of NT proBNP in the study group was lower than that in the con group (P < 0.05). B. There was no remarkable difference in serum CK-MB between the two groups after treatment and before treatment, and there was no remarkable difference between the two groups in it (P > 0.05). C. The serum cTnI level of the two groups was the highest 6 h after treatment, and the serum cTnI level of the study group was lower than that of the con group (P < 0.05). D. The serum IL-10 level in the two groups was greatly higher than that before treatment (P < 0.05), and reached the peak at 6 h after treatment, and the level in the study group was greatly higher than that in the con group (P < 0.05). There was no remarkable difference between the two groups at 24 h and 48 h after treatment (P > 0.05). Note: t0 h: before treatment, t6 h: 6 h after treatment, t24 h: 24 h after treatment, t48 h: 48 h after treatment; * indicates that in contrast to the study group, *P < 0.05.

groups were improved compared with those before treatment (P < 0.01), and there was no remarkable difference between the two groups (P > 0.05).

Comparison of postoperative complications between the two groups

Among the 45 children who had successfully transcutaneous VSD closure guided by ultrasound, 5 children suffered from early residual shunt, 2 suffered from slight arrhythmia, and 3 suffered from tricuspid regurgitation. The total incidence of complications was 22.22%. Among the 49 children who had successfully transcutaneous closure of VSD, 4 children suffered from early residual shunt, 3 suffered from slight arrhythmia and 5 suffered from tricuspid regurgitation, with a total incidence of 24.49%. There was no remarkable difference in the incidence of postoperative complications between the two groups (P > 0.05) (**Table 5**).

Influencing factors of complications

A total of 94 cases of successful percutaneous VSD closure guided by ultrasound and radiation were divided into two groups according to complications. Data of the two groups were analyzed by univariate analysis, as shown in **Table 6**. There were differences in VSD diameter, occluder diameter, superior margin to aortic valve and operation time between the two groups (P < 0.05). Indexes with differences in univariate analysis were included in the assign-

Table 3. Comparison of serum factor levels before and after treatment ($\bar{x}$ ± SD)

	NT-proBNP (μg/L)	CK-MB (U/L)	CTnI (μg/L)	IL-10 (pg/ml)
Research Group				
T0 h	127.65±34.38	25.69±4.23	2.26±0.28	518.26±110.37
T6 h	387.46±40.87	27.47±5.21	5.63±0.54	729.87±131.87
T24 h	896.38±87.32	26.59±5.02	2.62±0.37	698.21±124.39
T48 h	687.37±57.72	25.88±5.47	2.40±0.29	658.28±106.32
F	1581.00	1.25	840.50	29.67
P	< 0.01	0.29	< 0.01	< 0.01
Con group				
T0 h	129.31±38.79	26.04±4.32	2.37±0.33	513.78±109.29
T6 h	508.47±55.76*	27.66±5.34	8.79±0.96*	684.79±123.27*
T24 h	1067.38±109.67*	26.71±5.96	2.67±0.41	673.28±113.24
T48 h	735.21±64.12*	26.11±5.42	2.42±0.27	624.97±114.21
F	1558.00	1.043	1628.00	23.90
P	< 0.01	0.38	< 0.01	< 0.01

Note: *indicates that in contrast to the study group, *P < 0.05.

Table 4. Changes of cardiac function indexes before and after treatment in two groups ($\bar{x}$ ± SD)

	LVEDD (mm)	LVEDV (ml)	LVESV (ml)	LVEF (%)
Research Group				
Before treatment	57.98±7.71	114.01±8.12	97.77±6.42	37.12±7.01
After treatment	48.72±6.11	91.32±6.14	80.23±5.34	47.12±6.04
t	6.23	15.12	13.77	7.25
P	< 0.01	< 0.01	< 0.01	< 0.01
Con group				
Before treatment	58.23±7.53	113.79±8.02	96.49±7.09	46.79±6.31
After treatment	52.02±6.72	91.89±5.99	82.01±5.13	37.81±6.93
t	5.14	15.45	12.04	6.43
P	< 0.01	< 0.01	< 0.01	< 0.01

ment (see **Table 7**), and the results of risk factor Logistic regression analysis are shown in **Table 8**. It can be seen that VSD diameter (HR: 0.109, 95% CI: 0.026-0.448), occluder diameter (HR: 5.231, 95% CI: 1.310-20.888), superior margin to aortic valve (HR: 6.538, 95% CI: 1.633-26.188), operation time (HR: 0.912, 95% CI: 0.865-0.963) were independent risk factors for complications of VSD patients.

Discussion

With the development of science and technology, treatment, anesthesia and postoperative nursing, the prognosis of VSD after surgical closure has improved significantly over time. However, residual shunt, conduction system disorder, nerve injury, and postoperative mortality are still the main postoperative complications, especially in children with malnutrition [20, 21]. At present, percutaneous VSD closure has become a crucial treatment of VSD [22]. However, due to the use of contrast media and radiation, the traditional interventional therapy will increase the risk and damage of treatment [8]. In recent years, the application of echocardiography in interventional therapy instead of radiation has become one of the key measures to improve percutaneous therapy [23]. At present, the risk and severity of postoperative complications of VSD are considered as the key indicators to evaluate the value of surgical treatment [24]. Therefore, it is of great significance to study the influencing factors of postoperative complications of VSD.

NT ProBNP is primarily released by ventricular myocytes. In children with heart disease, the decrease of LVEF and increase of left ventricular end systolic pressure will enhance the mechanical stimulation of blood volume on the heart wall, thus promoting the synthesis and release of NT ProBNP [25, 26]. The results

Table 5. Comparison of postoperative complications between the two groups n [%]

		Early residual shunt	Arrhythmia	Tricuspid regurgitation	Complete atrioventricular block	Total incidence rate
Research Group	45	5 (11.11)	2 (4.44)	3 (6.67)	0 (0.00)	22.22%
con group	49	4 (8.16)	3 (6.12)	5 (10.20)	0 (0.00)	24.48%
X^2						0.11
P						0.74

Table 6. Single factor analysis [n (%)]/($\bar{x}$ ± SD)

	Occurrence group (n = 22)	Non-occurrence group (n = 72)	t/X^2	P
Gender			0.10	0.75
Male	12 (54.55)	42 (58.33)		
Female	10 (45.45)	30 (41.67)		
Age (years)			0.45	0.50
< 12	14 (63.64)	40 (55.56)		
≥ 12	8 (36.36)	32 (44.44)		
weight (kg)			0.00	0.96
< 30	9 (40.91)	29 (40.28)		
≥ 30	13 (59.09)	43 (59.72)		
VSD diameter (mm)			9.14	0.00
< 5	6 (27.27)	46 (63.89)		
≥ 5	16 (72.73)	26 (36.11)		
Occluder diameter (mm)			6.13	0.01
< 7	17 (77.27)	34 (47.22)		
≥ 7	5 (22.73)	38 (52.78)		
Superior margin aortic valve (mm)			4.26	0.04
< 3	15 (68.18)	31 (43.06)		
≥ 3	7 (31.82)	41 (56.94)		
Type of occluder			0.15	0.70
Symmetric type	14 (63.64)	49 (68.06)		
Asymmetric type	8 (36.36)	23 (31.94)		
Operation time (min)	55.72±12.56	40.13±12.11	5.24	< 0.05
NT-proBNP (μg/L)	128.15±34.09	128.67±36.31	0.06	0.95
CK-MB (U/L)	25.01±7.56	25.94±8.23	0.47	0.64
CTnI (μg/L)	2.33±0.31	2.29±0.52	0.34	0.73
IL-10 (pg/ml)	515.16±103.11	514.67±97.18	0.02	0.98

Table 7. Assignment table

Factor	Assignment
VSD diameter	< 5 mm: 1, ≥ 5 mm: 2
Occluder diameter	< 7 mm: 1, ≥ 7 mm: 2
Superior margin aortic valve	< 3 mm: 1, ≥ 3 mm: 2
Operation time	Data belongs to continuous variable analysis with original data

revealed that the NT proBNP level in serum reached the peak at 24 h after treatment and began to decrease at 48 h, and the water level of NT proBNP in the study group was lower than that in the con group (P < 0.05). It has been reported that NT ProBNP will be up-regulated in

Table 8. Multi factor analysis

	β	SD	X^2	P	HR (95% CI)
VSD diameter	-2.220	0.723	9.433	0.002	0.109 (0.026-0.448)
Occluder diameter	1.655	0.706	5.486	0.019	5.231 (1.310-20.888)
Superior margin aortic valve	1.878	0.708	7.034	0.008	6.538 (1.633-26.188)
Operation time	-0.092	0.027	11.176	0.001	0.912 (0.865-0.963)

the early stage after interventional treatment of ASD, and it will return to normal value during further follow-up [26], which suggests that NT ProBNP can reflect myocardial injury and NT ProBNP can reflect myocardial injury. CK-MB mainly exists in myocardium, which is of great significance in the diagnosis of myocardial injury. It can catalyze ATP and creatine to produce creatine phosphate as the energy reserve of cardiomyocytes. When myocardial ischemia injury occurs, CK-MB can catalyze the reverse reaction of adenosine triphosphate and creatine, leading to the first reduction of creatine phosphate level. Additionally, the enzyme is released into the blood due to the damage of myocardial cells [27-29]. There was no significant difference in CK-MB level among the three volatile anesthetics used in children with VSD closure [30]. The results of this study showed that there was no significant difference in serum CK-MB between the two groups after treatment and before treatment, and there was no significant difference between the two groups ($P > 0.05$). Cardiac troponin (CTN), a muscle contraction regulating protein, exists in the form of complex in vivo. When cTnI maintains the stability of tropomyosin by binding to actin and blocks the entry of its myosin binding site, the cardiac diastolic function is relaxed. There are 6%~8% free cTnT in the cytoplasm of cardiomyocytes. When myocardial injury occurs, cTnT is released into the blood and the level of Serum cTnT increases [31, 32]. Saraiya [33] found that serum cTnI was significantly increased in neonates after cardiac surgery, and showed a peak value 6-24 h after surgery. The results showed that the serum cTnI level of the two groups was the highest at 6 h after treatment, and the serum cTnI level of the study group was lower than that of the con group ($P < 0.05$), which suggested that cTnI level was more effective than CK-MB in reflecting myocardial damage, and VSD closure under the guidance of ECG played a better role in protecting myocardial damage. IL-10 is a strong anti-inflammatory cytokine, which is mainly produced by Th2 lymphocytes, monocytes/macrophages and regulatory T cells. It can inhibit the production of pro-inflammatory factors by Th1 lymphocytes, thus improving the proliferation, survival and antibody production of B lymphocytes. It can also regulate the effect by inhibiting the activation of T cells and reducing the expression of antigens [34]. Fang [35] found that the level of IL-10 in valved bovine jugular catheter was significantly higher than that in valved bovine jugular catheter. It has been reported in the literature that the level of serum IL-10 in patients with congenital heart disease after transcatheter closure and implantation of domestic occluder is significantly increased [36]. This study showed that the level of IL-10 in the two groups significantly increased after treatment ($P < 0.05$), with the peak at 6 h after treatment, and the level of IL-10 in the study group was significantly higher than that in the con group at 6 h after treatment ($P < 0.05$), but there was no significant difference between the two groups 24 h and 48 h after treatment ($P > 0.05$), which suggested that the two treatments can improve the level of IL-10, so as to relieve the tissue damage caused by inflammation and reduce the risk of bleeding.

It has been confirmed that the transcutaneous atrial septal defect guided by ultrasound and electrocardiography can be used as an alternative to fluoroscopy guided surgery, which has high application value [37]. In this study, by observing the operation of the two groups, it was found that there was no significant difference between the study group and the con group in the success rate of operation, length of stay and other basic conditions ($P > 0.05$). The operation time, occluder diameter, equipment cost, and total cost of the study group were lower than those of the con group ($P < 0.05$), which implied that percutaneous VSD closure guided by echocardiography can effectively reduce the operation time and cost, and has a high clinical value. This is similar to the research results of Liu [23], and it is suggested that the operation of the ultrasound guided group is relatively simple. It does not need intraoperative high-pressure angiography, femoral vein puncture and special equipment. The results showed a remarkable difference between VSD patients and healthy people (P < 0.05) [38]. Some studies have found that the cardiac function of children changes after VSD closure via catheter using speckle tracking echocardiographer [39]. Yuan [40] revealed that transcatheter closure of ASD could significantly improve the cardiac function indexes such as LVEDd, LVEDV, LVESV, and LVEF. This study revealed that there was no significant difference in cardiac function between the two groups before treatment. After treatment, LVEDd, LVEDV, LVESV, and LVEF in the two groups were improved compared with those before treatment, and there was no significant difference in LVEDd, LVEDV, LVESV and LVEF between the study group and the con group after treatment (P > 0.05). It is suggested that echocardiography and percutaneous VSD closure under the guidance of radiation can improve the heart function of children and restore the left ventricular function with little difference. Residual shunt is the main complication of VSD transcutaneous closure, with an incidence of 25.5%. Other complications include cardiac arrest, aortic valve and tricuspid regurgitation [23]. Complete atrioventricular block is the most serious complication, with the incidence of 0-5.7% [41, 42]. It has been found in the study of transcatheter closure of atrial septal defect under the guidance of transthoracic echocardiography in foreign countries that this method has high safety and few complications [43]. The results showed that the incidence of residual shunt and tricuspid regurgitation was higher, and the incidence of complete atrioventricular block was 0%. There was no significant difference between the complications of ultrasound-guided percutaneous VSD closure and that of radiation-guided percutaneous VSD closure (P > 0.05). The risk factors of arrhythmia after transcatheter closure of congenital perimembranous ventricular septal defect were studied, and it was found that eccentric, large occluder and long fluoroscopy time were the risk factors of postoperative complications. One study by Zhang et al. [44] on analysis of risk factors for arrhythmia after VSD occlusion in children showed that the size of occluder, male, body weight, asymmetric occluder placement, and foreign occluders were all related to the occurrence of postoperative complication of arrhythmia. The results of logistic regression analysis revealed that the diameter of VSD, the diameter of occluder, the distance between the upper margin and aortic valve, and the operation time were all independent risk factors for the complications of VSD patients.

This paper has mainly discussed the application and clinical value of percutaneous VSD closure guided by echocardiography, but there are still some limitations. Because of the small sample size, a large number of multicenter studies are needed. Moreover, in this study, there are few observation indexes, which may be missed in the analysis of related factors that cause complications, and further research is needed. In the future research, we should follow up the long-term curative effect and complications of the children, so as to reduce the complications to a greater extent and improve the therapeutic effect.

Conclusion

Percutaneous VSD closure guided by echocardiography alone can significantly improve the cardiac function and reduce myocardial injury, which has a good clinical value. The size of VSD, the diameter of occluder, the distance between the upper margin and aortic valve, and the operation time are all the factors influencing the postoperative complications.

Disclosure of conflict of interest

None.

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