The treatment of pectus carinatum with the bracing after surgery for congenital heart disease: experience from a single institution

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Abstract

Purpose:Secondary pectus carinatum (PC) after surgery for congenital heart disease(ChD) has its own clinical characteristics.Conservative treatment of PC with bracing is an attractive alternative to surgical repair.This study was to investigate the effects of the bracing on treating pediatric patients with PC after heart surgery.

Methods:We conducted a retrospective study of all patients who had PC after surgery for ChD with median sternotomy from March 2019 to December 2020.Monthly follow-up with anterior–posterior(AP) width measurements.The size of bracing is designed based on the patient’s anterior chest wall.

Result:Twenty four patients (3/2019–12/2020) were conducted into this retrospective study in the clinic,and 22 patients(91.66%) achieved excellent correction.The twenty four patients were distributed into three stages(stage 1: treated for 0 month,stage 2:treated for 3 months, stage 3: treated for 6 months).We found statistically significant differences in the AP between stage 2 and stage 1(AP $p<0.01$),stage 3 and stage 2(AP $p<0.01$).The main side effects were mild subcutaneous hematoma,petechial bleeding and chest tightness.There was no children complicated with hydropericardium or cardiac tamponade.

Conclusion:The bracing has been shown to be a safe and effective approach for the treatment of the pediatric patients with PC after surgery for ChD.

Introduction

Sternotomy is usually used in surgery for ChD.The PC is characterized by protrusion of the sternum and costal cartilages.It is the second most common type of chest wall deformity.[i]Respiratory function tests show no significant pathological changes in these children.If accompanied by scoliosis, restricted respiratory dysfunction may be found.[ii][iii]Pediatric PC patients may have shortness of breath and symptoms of chest pain, especially during exercise.¹In addition to the physical symptoms, the deformity can cause cosmetic and psychological problems.During adolescence, the deformity becomes more prominent as the growth rate increases.Some pediatric patients after surgery for ChD usually combined with PC.In the clinic we met some of these pediatric patients with PC secondary to ChD surgery(fig.1).These pediatric patients are temporarily exempt from social and psychological problems.But their parents are very anxious about their chest wall deformity.As the children get older,they may have negative physical self-esteem and poor quality of life.[iv]Presumably, correcting their chest wall deformities improves self-esteem and confidence.[v]Until recently, corrective methods for patients with PC included aggressive surgical interventions in the form of open or modified Ravitch or minimally invasive procedures.[vi][vii][viii]Conservative treatment of PC avoids operative intervention and possible complications,has no scars,and cost less than surgery.⁸[ix]In many studies, bracing have had very satisfactory results in adolescents.^{1,6,9}[x]But there is no study has examined the the effects of bracing on

pediatric patients with PC after CHD surgery. The aim of this study was to examine the effectiveness of bracing to correct PC in pediatric patients secondary to CHD surgery.

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Methods

The study was approved by the Medical Ethics Committee of Fujian Provincial Maternity and Children's Hospital (the date of IRB approval was April 06, 2020, the IRB approval number is 2020-KY-039). All of our

patients were under the age of 18 and we obtained informed consent from the parents. The method of treating for pectus carinatum with bracing is in accordance with guidelines published by the American Paediatric Surgical Association.^[1]

Patients

We conducted a retrospective study of all patients who had PC after surgery for CHD with median sternotomy from March 2019 to December 2020. The exclusion criteria were as following: having a chronic systemic disease, having complex and mixed type chest wall deformity and being unwilling to use orthosis. The indications for intervention with a bracing were as such: failure to meet the operative criteria, being unwilling to surgery, being compression test positive, and having a pressure of correction under 10 per square inch. At the clinic, patients had the option to undergo surgery or bracing therapy. And most of them preferred to choose the conservative treatment. Echocardiograph, coagulation function and electrocardiograph was routinely performed before the daily application of the bracing to evaluate the patient and exclude cardiac insufficiency. Data collected included the patient's age, height, weight, chest wall measurements, associated features, associated symptoms and medical history. Patient characteristics are shown in table 1. All pediatric patients should be supervised by caregivers at home. Compliance is the key to permanent correction of the pectus carinatum deformity.

Patients wore a snug fitting undershirt under the bracing (fig.2) at all times to prevent skin breakdown. Within the first week, bracing was used for at least 2h a day to increase the tolerance of the chest wall. The use time was gradually increased to 8h a day at week 2 and increased to 23h a day in one month. Patients should be followed up every 3 months according to the schedule. Using bracing for the first time, the patients should be kept in the clinic and observed for at least half an hour. The pressure for initial correction was measured in all patients. We recorded the pressure of bracing. We tried to flatten the protrusion of the sternum and costal cartilages at the first time when the patients' parents decided to start the treatment. If there was chest pain, chest tightness, palpitations or other persistent symptoms, we reduced the pressure.

Because of the outbreak of novel coronavirus 2019, many patients faced travel restrictions. Patients should be continued to be followed to ensure that their chest remains flat. For those patients who had not returned the clinic after 3 months, we contacted them by WeChat (a popular Chinese mobile messenger app). With the help of WeChat, we could communicate with parents more easily and often.

Every time the bracing was adjusted, it should be monitored by the outpatient doctor, and gradually increased the pressure to flatten the protrusion according to the tolerance of the children. If there was chest pain, chest tightness, palpitations or other symptoms, we stopped the treatment immediately. It should be alert for heart damage. Echocardiography could help us to diagnose. Reducing the pressure and the using time could help most of the patients to continue the treatment.

Statistics

Statistical analysis was performed by using SPSS Statistics(version 25,SPSS Inc., IBM Company,Chicago,IL).The AP at 0 month,3 months,6 months were compared by the Friedman rank test, and the differences in the improvements among patients with different ages,sex,or symmetry classifications were compared by the Mann–Whitey U test.A p value less than 0.05 was considered statistically significant.

[i] American_Pediatric_Surgical_Association. Pectus Carinatum Guideline. APSA

Guideline 2012

https://www.eapsa.org/apsa/media/Documents/Pectus_Carinatum_Guideline_080812.pdf.

Results

Twenty four patients(6 females, 18 males)aged 35–120 months(median 55.0 months) adopted the device and were followed up regularly.The daily application of the bracing ranged from 2h to 23h(average 19.5h). The twenty four patients were distributed into three stages(stage 1: treated for 0 month,stage 2: treated for 3 months, stage 3: treated for 6 months). We found statistically significant differences in the AP between stage 2 and stage1(AP $p < 0.01$), stage 3 and stage 2(AP $p < 0.01$).The most common side effects were mild petechial bleeding (16.7%), thoracalgia (12.5%),Shortness of breath (12.5%) and palpitation (8.3%).

Discussion

The pediatric patients included in this study underwent median sternotomy after heart surgery had its own clinical characteristics.First,patients' chest wall is flexible.We could use less pressure to flatten the raised sternum.Second,steel wire was used to suture the sternum after heart surgery.At the end of an operation, the sternal wires are tightened by twisting the two ends together, and then the wires are bent over such that the tips of the wires are directed away from the skin.We could palpable fixation wire locally on the chest wall for some patients.In the process of brace compression,the wire increased skin wear, resulting in local skin swelling, bleeding, pain and other complications.Third,the patients had surgical scars on the anterior median chest wall.Some children were with scar constitution(Fig 3).In the process of brace pressure,the scar were tougher than the surrounding tissue, which would increase the discomfort of children and reduce compliance.These patients were more easily to make skin damage and even bleeding during brace compression.

Our aim is to learn the effects of bracing in the treatment of those patients with PC after CHD surgery.The effect of steel wire on the formation of PC patients remains to be further studied.Whether removing the steel wire has positive effects on the treatment of PC remained to be demonstrated.Because our young patients' chest wall are flexible,these pediatric patients may require longer periods of maintenance bracing.We advise these patients to brace for a few hours a day after achieving satisfactory outcome.

Echo tests show heart compression and strain in patients with PE, potentially warranting surgical repair with the Nuss procedure.^[i]^[ii] Because PC is not physically compressing the chest, cardiac evaluation is infrequently considered. However, in this study we also paid attention to the effects of braces on cardiac function. All the 24 children included in the study were regularly followed up by outpatient cardiac surgeons after heart surgery. Reexamination of echocardiography and electrocardiogram showed that the heart function were well.

In 2 cases, subcutaneous fixed wire in the middle of the anterior chest wall protrusion were obvious. We could palpate the wire clearly. Therefore, during brace treatment, we intentionally added a small pad to reduce friction and avoid skin lesions.

Surgical scars were obvious in the middle of chest wall in 5 patients. In the process of brace treatment, we also added a small piece of cotton pad to the scar to reduce friction and avoid skin lesions. Due to the presence of scar, the anterior chest wall discomfort was more obvious at the beginning of brace therapy in these children. However, after 1 month of adaptation, the scar became flatter and the children gradually tolerated the brace therapy.

We generally recommend that children start brace therapy when the weather is cool. So the children will wear more clothes. This can reduce skin problems caused by excessive sweating in children. At the same time, the cotton-padded clothes under the support can better protect the skin of children. In summer, because of the hot weather, we advised that children wear braces and stay in an air-conditioned room.

Kravarusic et al¹¹ reported significant improvement in subjective appearance was observed in patients who wore a compression orthosis for 23 hours daily. Colazza et al^[iii] detected that the patients were satisfied with the chest wall appearance after bracing treatment and their self-esteem increased. In another study, Thaker et al^[iv] investigated patients perception via a nonstandardized questionnaire. They concluded that patients improved self-esteem and satisfaction with their chest wall chest wall appearance. Sesia et al^[v] advised that the lateral expansion of the chest should be always considered, allowing breathing and chest expansion due to AP compression forces and natural growth.

In addition to orthosis, exercise should also be carried out to provide a better correction of the deformity of PC patients. If the bracing treatment fails, surgical repair is still a good choice.^[vi] Surgical correction is often used in the most severe cases. Patients with mild or moderate PC are usually do not undergo surgical correction.^[vii] Lee et al reported that skeletal maturity affects the correction of the deformity.^[viii] Emil et al^[ix] reported that older age, asymmetry and smaller first drop in pressure of treatment was associated with failure and longer orthosis use.

Limitations

This study has the following limitations. First the compliance of the pediatric patients and the parents are different. Second, AP may be influenced by fat thickness during the scanning process. Factors that may

influence the outcome of correction include skeletal maturation, patient growth, and flexibility of the chest wall. Further research is needed for long-term follow-up.

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Conclusion

In conclusion, bracing in PC patients after CHD is effective with close follow-up. Successful bracing treatment significantly improves chest appearance and self-esteem of pediatric PC patients. Considering

the noninvasive, minimal discomfort and high patient satisfactions, we believe that bracing treatment is an effective first-line treatment for many PC patients after CHD.

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Figures

Figure 1

Patient before treatment.

Figure 2

Patient wearing the external brace.

Figure 3

Patient with scar constitution.

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