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Case Report

Physical Medicine and Rehabilitation Section

Cardiopulmonary Rehabilitation along with Inspiratory Muscle Training to Improve Aerobic Capacity in Athletic Patient following Atrial Septal Defect Closure: A Case Report

CHITRAKSHI CHOBISA[1], VISHNU VARDHAN[2], NANDINI BAHETI[3]

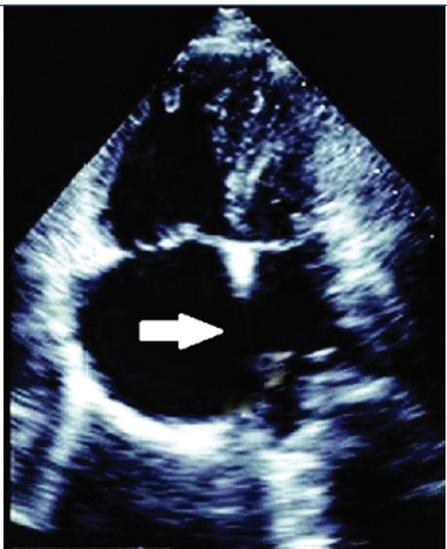
ABSTRACT

An Atrial Septal Defect (ASD) is a type of congenital heart defect in which there is an abnormal opening between the two atria. Hereby, the authors present a case report that describes a 16 mm diameter ostium secundum ASD that was diagnosed in an 18-year-old female district badminton player who came to casualty with chief complaints of difficulty in breathing while playing and an episode of syncope. After undergoing ASD closure surgery, cardiovascular rehabilitation and PowerBreathe device-assisted inspiratory muscle training were initiated. The present study emphasises the value of interdisciplinary treatment, including physiotherapy, to enhance overall functional status and respiratory function in the management of congenital cardiac disorders. Significant improvements were observed in pain, exercise ability, anxiety, and weariness, according to the end measures. In addition to highlighting the importance of these treatments in the postoperative care of patients with congenital heart disorders, the debate sheds light on the advantages of inspiratory muscle training and its possible effects on cardiopulmonary function. The present comprehensive approach, which combines pharmacological, surgical, and physical therapy treatments, has shown to improve patient outcomes and create opportunities for future advancements in the field of congenital cardiac disease management.

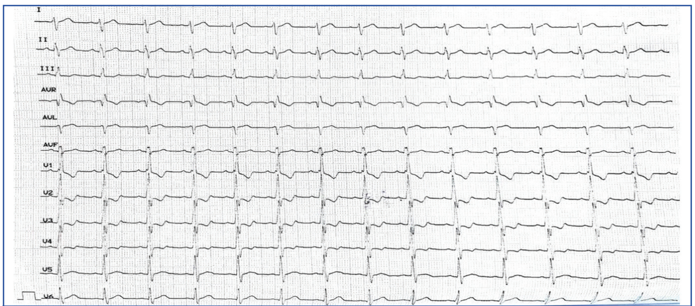
Keywords: Midsternotomy, Physiotherapy, Powerbreathe

CASE REPORT

An 18-year-old female district badminton player arrived at hospital with complaints of exhaustion, breathing difficulty while playing, and an episode of syncope that had been progressively worsening over the past week. No co-morbidities were noted. The patient was admitted to the ward, where a 2-dimensional (2D) echo was performed, revealing the presence of an ASD with a diameter of approximately 16 mm [Table/Fig-1]. An Echocardiogram (ECG) showed signs of right ventricular hypertrophy and complete right bundle branch block [Table/Fig-2]. Surgical closure of the ASD was recommended, along with first-line medication therapy. She underwent a midsternotomy for ASD closure six days after the diagnosis, which was performed by a senior Cardiac Surgeon, an Anaesthesiologist, the in-charge sister, and a ward boy. An autologous pericardial patch containing 5-0 prolene was used to seal the ASD. Following the procedure, on Postoperative Day one (POD-1), she was transferred to the Cardiovascular and Thoracic Surgery Intensive Care Unit (CVTS ICU), and a referral for physical therapy was made.



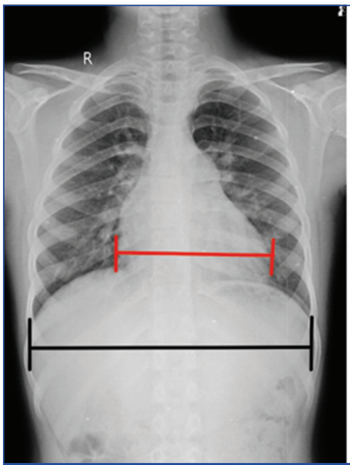
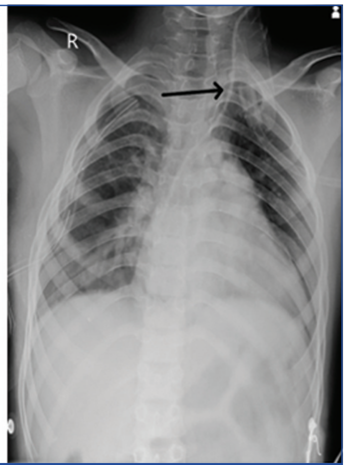
[Table/Fig-1]: A 2D Echo representing ASD of approximate 16 mm.



[Table/Fig-2]: Echocardiogram (ECG) representating right ventricular hypertrophy and complete bundle branch block.

On POD 1, a Physiotherapist visited the patient in the CVTS ICU. The patient was receiving six liters of oxygen via a face mask and complained of pain at the suture site and breathing difficulties. She was agitated, apprehensive, and concerned. Before the examination, informed consent was obtained from the patient's parents. The patient was assessed in a supine position, followed instructions, and displayed cognition and orientation. During the examination, the drains, Foley's catheter, central line, and femoral line were all in place. In the cardiovascular examination, the patient's blood pressure was 118/77 mmHg, pulse rate was 110 beats per minute, respiratory rate was 21 breaths per minute, oxygen saturation was 99%, and auscultation revealed normal S1 and S2 heart sounds. There was reduced movement of the chest wall. On auscultation of breath sounds, there was modest crepitation throughout the lungs and diminished breath sounds in the bilateral inframammary and axillary areas.

Clinical investigations: The ECG showed right ventricular hypertrophy and complete right bundle branch block due to a QRS duration exceeding 120 ms and a PR interval longer than 60 ms. The 2D echocardiography revealed a large ostium secundum ASD with a diameter of 16 mm. The preoperative chest X-ray displayed cardiomegaly and prominent cardiovascular markings, while the postoperative chest X-ray exhibited cardiomegaly and a central line [Table/Fig-3,4].

[Table/Fig-3]: Preoperative chest X-ray showing cardiomegaly and prominent cardiovascular markings. **[Table/Fig-4]:** Postoperative chest X-ray showing presence of central line. (Images from left to right)

- **Therapeutic intervention:** A Physiotherapist visited the patient twice a day, and routine monitoring and examinations were carried out. Rehabilitation sessions were conducted and their outcomes were recorded weekly. The events and their descriptions have been illustrated in [Table/Fig-5]. The goals were to alleviate dyspnoea, improve respiration, promote relaxation, enhance general functional status, and encourage early participation in athletic activities. A well-planned interventional protocol was implemented [Table/Fig-6] [1-3].

Timeline	Consultation	Description of events
After 1 week of occurrence of symptoms	Admission to hospital followed by diagnostic assessment	Difficulty in breathing while playing, fatigue, and an episode of syncope. 2D echo suggestive of ASD
After 6 days of diagnosis	Physiotherapy session prior to surgery	Patient education on the ailment and the physiotherapy treatment
On day of surgery	Surgery	ASD closure surgery via midsternotomy, and ASD was closed using an autologous pericardial patch with 5-0 prolene
On postoperative day 1	Postoperative Physiotherapy session started	Cardiopulmonary rehabilitation, including breathing exercises, sustained maximal inspiration, and active cycle of breathing technique along with inspiratory muscle training using PowerBreath medic plus
After 2 weeks of surgery	Discharged	Self-reliant daily functioning, strengthening exercises, and a well-designed home exercise regimen for the patient after discharge
After 15 days of discharge	Follow-up (after 2 week)	Initiating mild on-field physical activities

[Table/Fig-5]: Timeline of the events.

Goals	Physiotherapy treatment	Reasoning
Presurgical intervention included:		
To demonstrate forced expiratory technique and breathing exercises, as well as to inform the patient about the problem and the advantages of physical therapy intervention	Education and counseling for the patient's family. Deep breathing exercises and active cycle of breathing technique	Aids the patient in comprehending the problem more fully and executing the postoperative procedures more easily
Post-surgical intervention included:		
To apprise the patient of the advantages of the physiotherapy regimen	Counseling and education for the patient's family	To promote the patient's active involvement, thus improving the effectiveness of therapy
To reduce risk of cardiovascular, respiratory and integumentary complications	Air mattress was provided and every two hourly positional change was advised	To prevent risk of developing pressure sores and deep vein thrombosis
To enhance bed mobility and mitigate the risks associated with prolonged immobilisation	Supervised bed mobility training was inculcated	To prevent deconditioning
To alleviate strain on and around suture site	Chest binders	To reduce pain
To facilitate optimum lung functioning	Deep breathing and thoracic expansion exercise [Table/Fig-7] (10 repetitions, twice a day) Sustained maximal inspiration [Table/Fig-8] (3 sets of 10 repetitions)	Preventing atelectasis and the detrimental consequences of general anaesthesia
Preventing accumulation of secretions	Nebulisation Active cycle of breathing technique	Helps in maintaining bronchial hygiene
To improve the strength of respiratory muscles	Powerbreath medic plus device is used with intensity of 30% of maximal inspiratory pressure with 30 breaths against the device [Table/Fig-9]	Helps reducing respiratory muscle fatigue and increases aerobic capacity
To minimise stress, anxiety and depression	Buteyko breathing technique, Jacobson's relaxation technique	Aids in the patient's relaxation
To facilitate early and safe participation in athletic activities	Starting with mild interval aerobic training and returning to play	To improve aerobic capacity

[Table/Fig-6]: Represents concomitant, well-planned physiotherapy protocol.


[Table/Fig-7]: Patient performing thoracic expansion exercise.
[Table/Fig-8]: Patient performing sustain maximal inspiration using incentive spirometer. (Images from left to right)

Follow-up and outcome measures: The patient was evaluated preoperatively, on postoperative day 1, and after 2 weeks. Follow-up was conducted two weeks after discharge and is documented in [Table/Fig-10]. Outcome measures included the numerical pain rating scale, maximal inspiratory pressure using the PI Max device, the 6-minute walk test, the American Thoracic Society (ATS) scale for dyspnoea [4], incentive spirometry, the Fatigue Severity Scale [5], and the Beck Anxiety Inventory. Upon discharge, the patient received a comprehensive exercise program, self-monitoring techniques for vital signs, and guidance on recognising warning signs. She was provided with exercise guidelines and a daily activity tracker to follow at home to rebuild her strength and work toward her recovery goals. Breathing retraining exercises and hygiene practices were part of her daily routine. She was educated on relaxation techniques and methods to relieve dyspnoea for effective symptom management. Dietary advice included maintaining a high-protein diet to support muscle recovery and overall health. The patient expressed high satisfaction with the prescribed protocol, demonstrating a positive attitude, receptiveness, and enthusiasm for her progress. She

[Table/Fig-9]: Inspiratory muscle training performed by using PowerBreathe device.

Outcome measures	Prior to surgery	Postoperative day (POD) 3	After 2 weeks of surgery	After 4 weeks of surgery
Numeric pain rating scale	8/10	8/10	5/10	4/10
Maximal inspiratory pressure	35 cm of H_2O	27 cm of H_2O	31 cm of H_2O	38 cm of H_2O
6-minute walk test	400 m	NA	380 m	490 m
ATS scale for dyspnoea [4]	Grade 2	Grade 2	Grade 1	Grade 1
Incentive spirometer [5]	600 cc	Less than 600 cc	900 cc with 2 sec hold	1200 cc with 3 sec hold
Fatigue severity scale [5]	5.6	5.8	4.3	2.9
Beck anxiety inventory	22	23	16	9

[Table/Fig-10]: Represents improvement in various outcomes after the end of 4 weeks [4-6].

indicated a willingness to adhere to the treatment plan for as long as necessary, signaling a favorable outlook for her ongoing recovery and overall well-being.

DISCUSSION

A congenital heart disease is characterised by a significant structural abnormality in the heart or the major blood vessels within the chest, and this abnormality may or may not result in functional consequences [6]. One of the most common types of congenital heart defects, ASD, affects around 25% of infants. An ASD arises from an unclosed connection between the right and left atria. It includes anomalies that affect the actual septal membrane in addition to anomalies that permit communication between the two atria. From most common to least common, there are five different kinds of ASD: sinus venosus defect, ostium secundum defect, ostium primum defect, and patent foramen ovale [7].

Hereby, the authors present a case of an 18-year-old female patient who is a badminton player diagnosed with ASD and underwent corrective surgery for the same, after which she was referred to cardiopulmonary rehabilitation. After the repair of an ASD, athletes may benefit from cardiopulmonary rehabilitation in addition to inspiratory muscle exercise. Prior to and following defect closure, research assessed the ventilatory function and cardiopulmonary exercise capability in persons with ASD. According to the study, following ASD closure, cardiopulmonary exercise capacity increased [8]. Cardiopulmonary exercise metrics were slightly different between children with ASD and typical youngsters. The two most significant abnormalities were an increase in airway resistance during maximal exertion and a decrease in maximum oxygen absorption [9].

Using the PowerBreathe device, a clinical experiment conducted at the University of Colorado Boulder evaluated the impact of Inspiratory Muscle Strength Training (IMST) on blood pressure, heart attack risk, and physical and cognitive performance. According to the experiment, people who used the PowerBreathe even for a short while each day showed notable reductions in blood pressure and enhancements in large-artery performance [10]. The PowerBreathe gadget offers cardiopulmonary rehabilitation in addition to helping with sports performance and fitness. The National Health Service (NHS) in the UK has even authorised the PowerBreathe Medic for prescription usage, and PowerBreathe IMT is utilised by several prestigious organisations. In the contemporary uniformed services, where protective equipment may limit mobility and impede breathing, their breathing apparatuses might be utilised to prevent injuries [10]. Research suggests that using a breathing muscle-strengthening gadget for five minutes a day may help decrease blood pressure. With IMST, resistance is applied to your breaths as you inhale and exhale using a tiny, portable device [11]. The PowerBreathe gadget helps strengthen and enhance the breathing muscles by applying resistance to them. Strength and function of the respiratory muscles may increase as a result of this resistance exercise, which may enhance cardiopulmonary function [9]. IMT is helpful as a respiratory treatment to help athletes prepare for certain sports. Nonetheless, few research studies with excellent methodology are available [12]. One of the linear load resistor types now available on the market is Powerbreathe®, which produces resistance using either an electronic valve or a spring-loaded mechanism. The primary distinction between this tool and others is its capacity to provide the highest load during therapy and to modify inspiratory resistance in response to the pressure×lung volume curve. By giving the patient a sense of comfort, this feature may produce load stabilisation along the breath [13].

CONCLUSION(S)

The present case report sheds light on the comprehensive management of an 18-year-old female with a significant ASD through a multidisciplinary approach. The integration of open-heart surgery, postoperative care, and meticulous physiotherapy, including inspiratory muscle training with the PowerBreathe device, played a pivotal role in enhancing the patient's cardiopulmonary function and overall well-being. The successful outcomes observed in present case underscore the importance of tailored physiotherapeutic interventions, emphasising preoperative education, postoperative rehabilitation, and continuous support during the recovery period. Inspiratory muscle training, facilitated by innovative devices like PowerBreathe, emerges as a valuable adjunct in enhancing respiratory muscle strength and promoting optimal cardiopulmonary function. The findings not only highlight the efficacy of such interventions in the context of congenital heart diseases but also emphasise the potential applications in sports medicine and general respiratory health. The case underscores the significance of continued research and exploration of innovative approaches to improve the quality of life for individuals with congenital heart disorders. This comprehensive approach, encompassing medical, surgical, and physiotherapeutic interventions, showcases the potential for enhanced patient outcomes, paving the way for future advancements in the field of congenital heart disease management.

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PARTICULARS OF CONTRIBUTORS:

1. Postgraduate Scholar, Department of Cardiorespiratory Physiotherapy, Ravi Nair Physiotherapy College, Datta Meghe Institute of Higher Education and Research, Sawangi, Wardha, Maharashtra, India.
2. Professor and Head, Department of Cardiorespiratory Physiotherapy, Ravi Nair Physiotherapy College, Datta Meghe Institute of Higher Education and Research, Sawangi, Wardha, Maharashtra, India.
3. Intern, Department of Cardiorespiratory Physiotherapy, Ravi Nair Physiotherapy College, Datta Meghe Institute of Higher Education and Research, Sawangi, Wardha, Maharashtra, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Chitakshi Chobisa,
Postgraduate Scholar, Department of Cardiorespiratory Physiotherapy, Ravi Nair Physiotherapy College, Datta Meghe Institute of Higher Education and Research, Sawangi, Wardha-442001, Maharashtra, India.
E-mail: chitrakshichoubisa30@gmail.com

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