CONGENITAL DIAPHRAGMATIC HERNIA: POST-SURGICAL TREATMENT AND CHILD DEVELOPMENT

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ABSTRACT Introduction: Congenital diaphragmatic hernia is a condition with unclear etiology when an opening is formed in the diaphragm during the period of organogenesis. This opening enables abdominal organs to enter the thoracic cavity, making pressure on the lungs, heart, blood vessels, neural and other structures. **Purpose:** To present a patient at five years of age, born with a congenital diaphragmatic hernia and all of the accompanying conditions that followed after the surgery when he was released from the pediatric hospital, to be taken care at his home and evaluation of child development. **Material and Methods:** For this study, the medical history was observed of a child aged five. His paediatrician, his pediatric surgeon and other medical staff were questioned of all the procedures he had gone through. He was clinically examined with the methods of inspection, palpation, percussion and auscultation. Paraclinical methods like radiology and ultrasonography were also applied. Blood analyses were made. Every detail regarding his medical history compared to his current condition was noted in his medical record. **Results and Discussion:** Congenital diaphragmatic hernia is rarely an isolated condition. Unfortunately, many of the accompanying situations and conditions cannot be predicted while the child is in the womb or at his birth. **Conclusion:** Congenital diaphragmatic hernia is a very serious and delicate condition regarding the physical and mental health of patients and their families. As a condition with multiple pathological mechanisms, it needs constant monitoring for the wellbeing of patients. Families must be advised to make frequent appointments to the paediatrician, pediatric surgeon, children's cardiologist, otolaryngologist and all the other medical specialists to enable this patient an appropriate and abundant life and development like all normal children.

KEYWORDS Congenital diaphragmatic hernia, post-surgical treatment

Introduction

Congenital diaphragmatic hernia (CDH) is a condition with a high prevalence of its appearance. It is estimated that 1 in every 2500 live births is associated with the presence of CDH. This fact is rarely known even though CDH is as common as conditions like cystic fibrosis or spina bifida. During organogenesis, the prenatal period, there is a failure in the closure of the diaphragmatic muscle, thus enabling a path for migration of the abdominal organs to the thoracic viscera. When this occurs, there is a limitation in the space for the future development of the lungs, which may consequently result in pulmonary hypoplasia. That can lead to a reduction in the blood flow in the lungs, development of pulmonary hypertension, early development of asthma, gastrointestinal reflux, feeding disorders and developmental delays. [1] CDH is a serious, life-threatening condition, and it is of very high importance to be early detected prenatally so that families can plan what they can expect to know and how to organize

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their lives.

In an online dictionary of medical terms, CDH is defined as the passage of a loop of bowel through the diaphragm muscle. This type of hernia occurs as the bowel from the abdomen "herniates" upward through the diaphragm into the chest (thoracic) cavity. [2]

It is diagnosed that the diaphragm develops during the 4th–8th week of gestation, and the hernia is thought to occur when the pleuroperitoneal folds and septum transversum fails to converge and fuse. [3] Posterior lateral hernias, also known as Bodaleck account for >95% of neonatal diagnoses with 85% occurring on the left side. Anterior retrosternal or parasternal CDHs (Morgagni) account for 2% of all CDH cases. [4, 5]

CDH may occur as an isolated defect, but 40% of CDH cases are non-isolated and have at least one additional anomaly. [6, 7] Aneuploidies, copy number variations (CNVs), and cytogenetic rearrangements involving almost all chromosomes have been described with CDH. Holder et al. published a detailed review of all reported cases of chromosome anomalies in CDH and chromosome microarray analysis which has expanded the understanding of recurrent CNVs associated with CDH. [8]

Still, for CDH, there is a sea of material known. Yet, this is insufficient to understand all mechanisms because there is a genetic aspect of its appearing that further needs to be researched and compare in medical history.

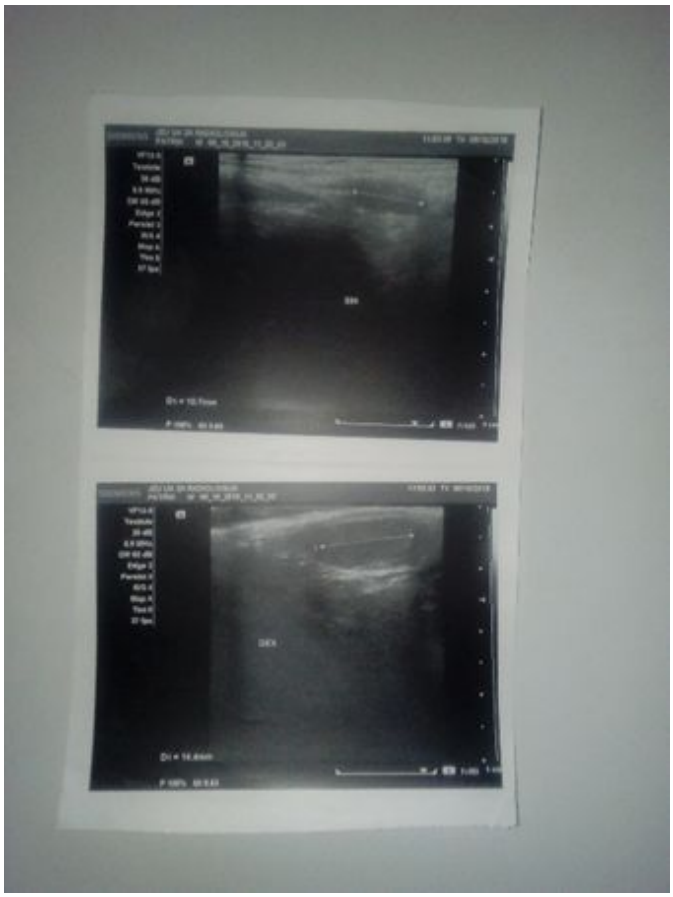

Figure 1. Pictures from ultrasound scanning of the testicles before surgery.

Figure 2 a, b The boy with CDH, from birth till 5-years-old.

Purpose

The purpose of this article is to present a study of a 5-year-old child from the period of his surgery until his five years and two months of age. It is of high importance to emphasize the struggle that parents of CDH babies and medical staff go through to help themselves and other children with this anomaly. Also, it is important to understand the different and various phenomena, diseases and conditions that occur in early childhood development in these children.

Materials and Methods

As a material, a 5-year-old boy was followed from his birth until his fifth birthday and two months of age. He was diagnosed with the condition congenital diaphragmatic hernia intrauterine, at his left side of the diaphragm and was monitored to be operated. On the results from his mother's amniocentesis, his karyotype was normal as any other child and did not have any chromosomal anomalies.

As methods X-rays, ultrasonic examinations, blood tests, everyday observations, inspection, palpation, percussion, auscultation, mental health analysis, cognitive and motoric skills and many other medical procedures were applied for better diagnosis, monitoring and follow up.

After 17 hours of his birth, he was operated from his condition and was hospitalized at the intensive unit in the pediatric clinic in Ljubljana, Slovenia. When he was born, he was intubated and sedated with many tubes with infusion applied in his veins. He had quite a rapid recovery, and he was extubated at the five days after birth and at the eight days after surgery he was dislocated to the semi-intensive unit with his mother. After 15 days from his birth, he was sent for the proceeding at-home treatment with his mother, his paediatrician (the grandmother) and his family. The baby was monitored daily, having difficulties breastfeeding. This was taken care of by feeding him slowly with a combination of pumped mother's milk and formula milk from sterilized bottles. He needed to be sleeping in an upright position to prevent suffocation. X-rays are taken after his CDH surgery showed underdeveloped left lung. On his physical inspection, a mild deformity of the thoracic cage was observed. Besides the start in his life, the baby was developing normally, for the first days in his life. Being transferred into the semi-intensive unit, he started to sneeze experiencing his first cold contact as it was winter when he was born (from previously being on the warmer in the intensive neonatal unit). There existed a skin discolouration on the left side of his back which was observed to be on the same level as his remaining skin. At the same time, his left testicle became mobile at the time his mother changed his diapers.

When he was one month old, the baby was breastfeeding with a combination of mother's and adapted milk. On inspection, he had a mild deformity on his thoracic cage. The changes on

his skin were observed like a plum-coloured strawberry at his back, localized on the left side, which was in the level of the skin. His left testicle was still mobile at changing or taking baths. He still had to be fed in an upright position because he had blue discolouration on his face when he was lying down and drinking milk. Being tested for the motoric skills, he had normal results. His results for thyroid function were also normal. Blood analysis made at that time did not show any significance and were without any particular findings.

As the child was growing the changes grew with him. At three months of age, his strawberry was becoming larger and started to elevate above the remaining skin on his back. His left testicle was still mobile and was moving toward the abdomen. He caught an infection which he rapidly managed to combat. With the methods described for examination, he had normal findings.

At six months of age, he still had developed thoracic deformity, because he was growing normally, progressively. However, his lugs hadn't been fully developed, which is why he had acquired torticollis and was wearing a Stance's collar. His skin change was growing. His left testicle was not the same size as his right one because it was mobile and more localised in the abdomen. At this time he had his first vaccines taken which he had taken well without any complications.

At seven months of age he said his first word-grandmother (baba), and after that in the same month mother, father and grandfather. At the same month, he had his first tooth. He was developing normally in motoric skills and mental health. However, at that time, he had his first serious infection on his throat, which rapidly spread to his lung. He was suffocating, had a swollen stomach and was in a severe condition, not being able to move from his bed. He was given antibiotics, corticosteroids, aminophylline, vitamins and needed two weeks to heal.

At his first birthday, he was already walking steadily, developing normally mentally and physically. Physically he did not differ from babies his age. His thoracic cage was more symmetrical now, and he did not need to wear his neck collar. He had another bronchopneumonia not so severe. He had an ear infection as well. Every infection he had starting from a mild nose run for a couple of days spread rapidly in his lungs, making him cough and even suffocate, not being able to breathe and take air normally. At this period his hemangioma localized on the left side had already grown the size of a clementine. His left testicle was still moving and was underdeveloped compared to his right one.

When he was 15 months of age, he had another infection. This infection also began from a mild nose run to a serious cough resulting in bronchopneumonia and in need of a suitable therapy: antibiotics, corticosteroids, aminophylline and other medications for relieving the symptoms. Physically and mentally, he was developing normally like every other child. But his back skin change was diagnosed to be a growing hemangioma. The strawberry hemangioma was warm at inspection and even had ulcerations. The hemangioma was treated with a propranolol crème, but it did not react to the therapy. His left testicle was more present in the abdomen and less in the scrotal sac, not allowing it to grow normally.

At 22 months of age on the results from his physical and mental examinations came normal. His blood analysis was also normal. His X-ray taken from his chest showed that his lungs had developed equally. He had symmetrical findings on his thoracic cage. At that time, he was sent to a pediatric surgeon who recommended that his testicle need to be operated because it was not developing (figure 1). This was confirmed by ultrasound scanning diagnosis. Also, on his paediatrician recommendation, he was administered for surgery to remove his hemangioma. He had another serious lung infection for which his operations were cancelled for a month.

At 23 months of age, he had both surgeries at the same time: removal with total excision of his hemangioma and descending of his testicle. The operations were successful, and after two days, the child was administered to be taken care at his home. He was recovering quite well but had many nightmares form the operations. He was screaming at night and needed comfort from his parents. After the removal of the stitches, the mother was advised to use crèmes and patches with medications for healing faster. Because he lost some amount of blood and from the stress, the child again developed severe bronchopneumonia coughing and suffocating.

After his second birthday, he was in need to sleep with his parent, still having fears. Before that time, he had slept in his bed alone, from the moment he was born until the surgeries. The physical examination stated normal development, but the child had started having mental delays. He refused to speak. The few words he had known have vanished from his dictionary.

At two years and two months of age again, he had another lung infection. He was taking vitamins on a daily bases and recovered fast. His paediatrician stated that she worries about his mental development, in terms that he showed signs of delay.

At two years and eight months, he had another very severe bronchopneumonia in need for two antibiotics, corticosteroids, aminophylline, nose spray and many other medications. At this time he had serious delays in his mental behaviour. He was babbling, but he lacked contact. He stared at the television or computer and did not communicate with the close people around him or with strangers. He was diagnosed to have an autistic element in his mental development. Because of these factors, he started taking speech therapy and was monitored for having slow progress in the process.

At two years and ten months, he again had a severe lung infection. At this time physically, he had normal development. Mentally he started to have a loss in appetite. His speech therapy was going slow in progress. He was functioning like a one-year-old. He did not have acquired habits for urinating and defecating outside his diapers.

With the detailed help from his paediatrician, he started to have step by step one new word in a day. He was taking a combination of vitamins, minerals, amino acids, and other medications like piracetam, gamibetal buxamina, acutil fosforo for mental brain stimulation.

Progress was seen after his third birthday in his mental development. He still did not have hygiene habits. But his development was in progress. He was communicating with people, sometimes being very stubborn. He was eating normally. Physically he doesn't differ from toddlers his age. He is estimated to function mentally like a 2-year-old. His lungs are developed normally. A little after his third birthday, he had another two lung infections with extremely high temperatures (fevers). He was examined by his pediatric surgeon to have normal testicle. He stated that the surgeries are successful. The hemangioma was completely removed. His testicle was growing normally having almost reached the size of the healthy right-sided one.

At the last control his blood analyses were normal except for the elevated monocytes. There persists a suspicion of a possible

dust allergy that yet needs to be analyzed with skin patches.

His parents, grandparents, aunts and every doctor involved have played a great role from the prenatal diagnosis, from his first surgery, following his body changes, his other two surgeries, and mental delays. They have been involved in the entire process for enabling him an abundant life not to notice the difference from his healthy sister and other toddlers his age.

When he was three years, he started going to kindergarten. At first, he got used to it and adjusted for a few hours and after that for days. Adaptation went slowly at first but later was improved. But after three months he was tested positive for streptococcus pneumoniae in his nose and throat. Again the infection spread directly to his lungs. Medications were prescribed, and the treatment was well received. However, the kindergarten was not recommended because of his health condition and was therefore interrupted. His childhood development was continued by a baby sitter who kept him at home.

Compared to his older sisters, he has a gentler organism, and can easily be infected. Every infection spreads directly to the lungs, like an undiscovered mechanism that needs constant and awake monitoring.

At the age of 4, he started going to the kindergarten, having a positive atmosphere, but followed by periods of infection and more often stayed at home. His parents' notices positive changes when he was taken to the sea to strengthen his immune system and to make his easily combat every infectious battle. In comparison, when taken to the pool, he developed a suffocating situation from the disinfections of the closed system of water.

At the age of 5, there were positive changes in his development. He has grown physically and mentally and has begun to show interest in the environment in which he lives and is educated. The special interest he arises for children's games, computers, mobile phones, cartoons and strives to socialize in every environment. Occasionally he goes to kindergarten but often gets sick again and again. It is still susceptible to infections, especially on the lungs. It happens to rise to a high temperature and above 40 degrees Celsius, which creates serious frustration in the family and doctors. Knowing his development and the surgeries he has undergone, regular follow-up and consultations with specialist doctors greatly help the family to adapt to the sensitive health and the changes that are taking place. Based on the experience gained and the awareness of the condition as a person with CDH, the occurrences and diseases are more clearly foreseen and on that basis the medicines measures and the treatment for its healing support his child development.

Research and Discussion

From the methods used in the five years follow up study, we have obtained several results. The child born with a congenital diaphragmatic hernia can have multiple problems regarding his health, which cannot be predicted when the child is in the womb.

In the literature, it is stated that a broad spectrum of morbidity can persist in children who are survivors. Peetsold et al. have described multiple problems that can occur post-surgically in children born with CDH. One of them is the underdevelopment of the lungs which is the explanation of why the majorities of these children have a recurrent lung infection and have unexplained coughs. In this study, the patient has had many infections that began as mild runny nose and ended up to be life-threatening suffocating situations in which the parents must be alert to administer corticosteroids, aminophylline, and antibiotics and to awake monitor the child with the continuous help of his paediatrician, pediatric surgeon, otolaryngologist and other specialities if needed. It is unclear if there is an association between immune deficiency, underdevelopment of the compressed lungs and multiple serious recurrent infections. [9]

The closing of the defect of the diaphragm is just the beginning of a long struggle in which the child must be closely monitored at every stage of his development. This includes the changes that can occur at any time without warning. One of them is the association with the diaphragmatic hernia and the testicle problems. It can be associated that the weakness of the structures of the walls, muscles and membranes can be a start of problems that need close lookup.

Since the aetiology of CDH remains genetically unknown, no karyotype can be associated with its appearance. Rather than that, multiple etiological factors are connected to their appearance. Also, many accompanying conditions make the lives of these children difficult. In most cases, CDH is rarely an isolated defect. This is why it makes so difficult to diagnose, to predict future circumstances and yet to treat a child with CDH. Every CDH child is born unique. With a personal gene map, a defect in the diaphragm rarely persists alone, which need detailed surveillance and yet treatment to acquire the child's needs. [10, 11]

The chest and neck deformity have been resolved with exercise, with a neck collar and with water therapy. This has been seen in the literature where many chest and spinal deformities have been described. [12, 13, 14, 15]

This child at the day of his birth did not have any associated defects and had a normal chromosomal map and a normal karyotype. When the diagnosis is made in utero, amniocentesis is often performed for detecting chromosomal aberrations and may help to estimate lung maturity. [16, 17]

As stated in the literature, the main purpose is survival, and the wide range of figures reported are mystified and still unclear. When a hospital, postoperative results were reported, survival approached 70% or more, but the long term postsurgical findings need further investigation. [18, 19, 20, 21] Besides his multiple lung infections, the CDH survivor in this article had other issues that nobody predicted. One of them was his strawberry hemangioma. Nobody could even foresee its occurrence. The skin discoloration on the left side of his back around his scapula, which in the level of the skin had grown the size of a bigger clementine with warmness and ulcerations that bled. This hemangioma besides the mothers' persistence of using propranolol crème did not resolve itself and also needed surgery. The patohistological findings from the completely removed hemangioma described a benign tumorous formation with huge blood vessels and ulcerations at the outside skin particles.

The occurrence of hemangioma can be related to CDH, but this remains unclear. It is stated that multiple factors and mechanisms can be associated with CDH. The child, even in the hospital at the first days of his life had a mobile testicle that some doctors diagnose as cryptorchidism because of its localization and size. It was located on the left side like the opening in the hernia, which gives the doctors suggestion of the possible association of weak wall or facial muscle structures. Literature articles state that there is a connection between CDH and undescended testicles. This makes it possible that a deficiency of diaphragm tissue may affect the first or transabdominal phase of the testicular descent, leading to an increased incidence of undescended testicles (UDT). [22]

The testicle did not repair itself; it also needed successful surgery. After the operations from the anaesthesia, or from the medications, the child developed neurological problems deriving from autistic elements, not communicating, introversion, and nightmares to verbal dysphasia resulting in an unclear speech. With much care from his parents, grandparents, paediatrician, he is under therapy for immunity and speech. Neurocognitive and neurological outcomes are widely described in CDH survivors. Also, it has been realized that there is a risk for a lower level of cognitive functioning with increased levels of emotional and behavioural problems which require precise approaches to neurodevelopmental assessment. [23, 24, 25, 26]

His speech has slowly improved over the months but still needs much patience, work, rehabilitation and practice. In the last blood analysis, the child had elevated monocytes which can be in a high correlation with the multiple infections he has had and in an association with possible allergies especially to dust that need further to be examined.

The surgical closing of the CDH defect is not the end of the congenital abnormality. On the contrary, it is the begging of multiple problems that do not have predictable instructions to where they will appear and when. On the overall, the child is a happy toddler with physical no significant features, now, besides his scar (figure 2). The mental aspects of his development need to be worked upon for future progress so that there can't be a difference between his normal sibling and the children from his generation. That is why initial diagnosis is of high importance for family planning. It is very important to diagnose the condition intrauterine to prepare the parents of the possible conditions that follow the diaphragm defect and to give them all the courage and hope they will need.

Prenatal and postnatal advances in treatment have increased the survival of high-risk patients, and it is important to provide close follow-up and support for potential long-term morbidities. Long-term follow-up for infants with CDH is ideally provided at a specialized centre by a multidisciplinary team consisting of a pediatric surgeon, surgical nurse specialist, cardiologist, nutritionist, pulmonologist, and developmental paediatrician. This type of team can recognize, treat, and coordinate care for the many medical complications frequently found in long-term survivors with CDH described by authors. Genetic counselling must be taken into consideration for issues related to testing at-risk relatives and for the chances of future transmission of this anomaly on the next generations. [27]

Conclusions

Families of children born with CDH have to deal with a challenging condition because of its unpredictability and the long term need for constant examinations. Also, these families need to reorganize their lives in terms of plans, finances and schedules to ensure that their children with or without CDH are properly taken care of. Every step of the treatment has its advantages, disadvantages and consequences.

The congenital anomaly or condition CDH probably should be renamed as a CDH syndrome because of the multiple accompanying conditions it carries with the primary defect. Whether it is a lung problem, the problem with skeletal deformity, testicle problem, the problem with benign tumours or mental developmental problems parents should be informed from their paediatricians, pediatric surgeons, from other parents and most of all from the Internet, how to deal with this situations. Congenital diaphragmatic hernia as a severe and delicate condition regarding the physical and mental health of patients with multiple pathological mechanisms needs constant monitoring for the wellbeing of patients. Families must be advised to make frequent appointments to the paediatrician, pediatric surgeon, and all the other medical specialists to enable this patient an appropriate and abundant life like normal children. Of course, an individual health plan is needed that will record the measures are taken, and the medications are given, which will mean accumulated knowledge for all future needs of the child.

Further research needs to be performed in worldwide medical, scientific research centres so that prevention can take place. Special attention must be put to family planning. Genetic and family counselling is of very high importance so that families can plan their future to the benefits of the health of their most beloved ones.

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Author contributions

All authors attest that they meet the current International Committee of Medical Journal Editors (ICMJE) criteria for Authorship.

Conflict of interest

There are no conflicts of interest to declare by any of the authors of this study.

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