What is noncompaction cardiomyopathy?

Noncompaction cardiomyopathy (NCCM) is a form of cardiomyopathy still in the early phases of medical understanding. NCCM is also known as isolated noncompaction of the left ventricular myocardium, spongiform cardiomyopathy, or left ventricular noncompaction cardiomyopathy (LVNC). In some individuals, it appears to be caused by the abnormal development of the heart muscle before birth. In others, NCCM appears to develop after birth. In NCCM, the lower left chamber of the heart (left ventricle) contains bundles or pieces of muscle that extend into the chamber called trabeculations. Typically, trabeculations are located at the bottom tip or apex of the heart, but they can be seen anywhere in the left ventricle. There are different subgroups of NCCM based on heart function, thickness of the ventricles, heart chamber sizes, and presence of abnormal heart rhythms (arrhythmias). NCCM can occur in the presence of normal heart function or in association with heart muscle dysfunction where the heart does not squeeze normally. When NCCM occurs with normal left ventricular thickness, size, and function, it is called isolated NCCM. NCCM can occur in combination with abnormalities in heart squeeze (dilated form of NCCM) or in heart relaxation (hypertrophic or restrictive form of NCCM). NCCM may also involve the right lower chamber of the heart (right ventricle). The course of the disease and outcomes will vary based upon the NCCM subtype and prescribed treatment.

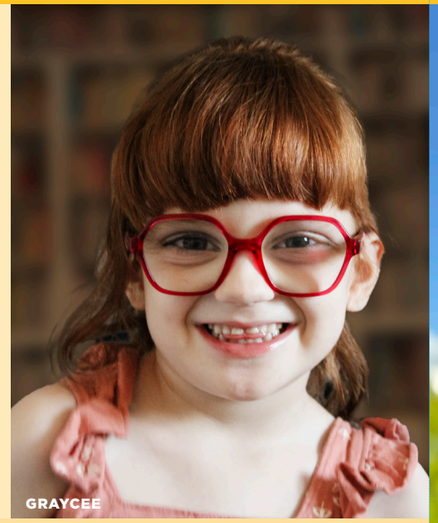
MACKENZIE

At just eight days old, **Mackenzie** was hospitalized with RSV and faced heart failure and arrhythmia related to her noncompaction cardiomyopathy (NCCM). She spent a month in the ICU and went home on seven medications. Today, she has plenty to smile about and loves sharing laughter with her big sister.

What is the prognosis?

Prognosis, or the likely course of a disease, in NCCM depends on many factors, such as a patient's age, existing conditions or health problems, the subtype of NCCM, and the presence or absence of arrhythmias.

In cases of more severe NCCM, prognosis may be similar to other types of cardiomyopathy advancing to heart failure. Increased awareness, early detection, careful surveillance and appropriate treatment by a cardiologist familiar with NCCM can greatly improve a child's outcome.



GRAYCEE

This booklet, featuring real children with cardiomyopathy, was created to provide families and caregivers with a broad overview of cardiomyopathy and is for general information only. The material presented is not intended to be complete or serve as medical advice. The information should not be a substitute for consultation with a qualified health care professional who is more familiar with individual medical conditions and needs.

The Children's Cardiomyopathy Foundation (CCF) is dedicated to finding causes and cures for pediatric cardiomyopathy through the support of research, education, and increased awareness and advocacy.

Register with CCF for additional resources: childrenscardiomyopathy.org

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UNDERSTANDING NONCOMPACTION CARDIOMYOPATHY

MASON & BENNETT

Children's Cardiomyopathy Foundation

How is NCCM diagnosed?

The diagnosis of NCCM is based on cardiac testing and physical exam, as well as family and medical history. During cardiac testing, an echocardiogram, computed tomography (CT) scan, and/or magnetic resonance imaging (MRI) may be used to diagnose NCCM. These imaging tests can reveal trabeculations and deep recesses within the heart wall, as well as measure the overall heart function, size of the trabeculations, and thickness of the compacted heart muscle. Multiple subgroups of NCCM exist, and symptoms may overlap with other forms of cardiomyopathy. In some cases, the heart may unexpectedly change its appearance from one form to another form over time. This is referred to as an "undulating phenotype" that is usually related to NCCM. A physical exam will also be done to look for evidence of heart failure and skeletal muscle weakness, which has been linked to certain forms of NCCM.

The evaluation will include a medical history taken of the child to look for any indication of heart failure. Signs would include feeding and growth issues, heart rhythm problems, and exercise intolerance. A detailed family history is done to determine if other family members have a history of cardiomyopathy, heart rhythm problems, sudden cardiac arrest or unexplained death, and any other heart disease or surgery.

All first-degree relatives (parents, siblings, and children) of an individual who has NCCM should undergo routine screening. Since NCCM can vary in presentation, it is possible to have NCCM without symptoms. A cardiologist and geneticist experienced in managing patients with cardiomyopathy can advise on the frequency of screening and the need for further genetic testing.

What causes NCCM?

Some evidence shows that NCCM can be caused by problems during the development of the heart in the embryo. In early fetal life, the inside of the heart contains pieces of muscles or trabeculations that extend into the heart chamber. During normal heart development, this sponge-like network of muscle fibers becomes compacted, transforming the trabeculations from sponge-like to smooth and solid. NCCM can occur when the compaction process does not happen normally, and the inside of the heart muscle remains trabeculated and spongy. Noncompaction has also been observed in individuals, typically in the setting of stress on the heart, where it was not observed previously. Some forms of NCCM can be inherited (familial origin) or it can occur spontaneously for unknown reasons (sporadic origin). Approximately 40 percent of individuals diagnosed with NCCM without other structural heart defects have a family history of cardiomyopathy, which can include NCCM, dilated, hypertrophic, or restrictive cardiomyopathy. NCCM is typically inherited in an autosomal dominant pattern in which a parent with a disease-causing mutation has a 50 percent chance of passing the mutation to each child. Although less common, NCCM can be inherited in an X-linked manner in which the mother passes the disease-causing mutation.

Once diagnosed with NCCM, there is a 20 to 40 percent chance that a genetic cause of the disease will be identified. Research has shown that mutations of the same genes known to cause dilated, hypertrophic, and restrictive cardiomyopathy may be found in NCCM individuals, which suggests some overlap among these conditions.

The majority of cases are caused by mutations in genes coding for sarcomeric proteins that are responsible for proper cardiac muscle contraction. There are other genetic mutations responsible for NCCM associated with genetic syndromes, metabolic or mitochondrial disorders, and neuromuscular diseases. There are not any known acquired causes of NCCM. If a genetic cause is found, ask your child's doctor whether close family members (like parents or siblings) should also be tested.

What are the common symptoms?

Symptoms can vary considerably and are determined by how the heart function is affected. Based on the subtype of NCCM that is diagnosed, symptoms usually overlap with those associated with dilated, hypertrophic, or restrictive cardiomyopathy. Children who have the structural features of NCCM, but normal heart function, may have no symptoms.

Those with a more severe form of NCCM may present with symptoms of heart failure or abnormal heart rhythm (arrhythmia). This may include shortness of breath (dyspnea), fatigue, unexplained weight gain or swelling (edema), dizziness or light-headedness (presyncope), fainting or passing out (syncope), abnormal heartbeat (palpitations), and limited physical capacity or exercise intolerance. Infants may experience excessive sweating during activity, difficulty feeding and poor growth.

There may be other complications related to NCCM, such as an increased risk of blood clots (thromboses), fast heart rhythms, and sudden cardiac arrest. Although the risk for sudden cardiac arrest is low, it increases with the severity of impaired heart function, and is best to be closely monitored by a cardiologist familiar with NCCM.

How many children are affected?

NCCM is a rare condition that affects less than 0.3 percent of the population. According to the Centers for Disease Control and Prevention, NCCM is estimated to affect about 1.2 per million children between 0 and 10 years of age. However, it is likely that many cases are overlooked and mistaken for dilated or hypertrophic cardiomyopathy. As new imaging techniques with higher resolution are being utilized, trabeculations in the heart are being detected more often, resulting in more children and adults being diagnosed with NCCM.

What are treatment options?

The goal of NCCM treatment is to improve heart function and prevent symptoms. The management of NCCM is influenced by its subgroup, and the resulting symptoms and diagnostic evaluation. Factors such as heart function, ventricle thickness, heart chamber size, and presence of arrhythmia will impact the treatment plan.

Due to the different forms of NCCM, treatment will address either a thick heart muscle (hypertrophic cardiomyopathy) or a poorly squeezing heart muscle (dilated cardiomyopathy). Medication is often used to treat symptoms, reverse heart damage, and prevent ongoing damage to the heart muscle. In patients with heart failure, anticongestive therapy, similar to that used in patients with dilated cardiomyopathy, may be recommended. This would include angiotensin-converting enzyme (ACE) inhibitors (captopril, enalapril), angiotensin receptor blockers (valsartan, losartan), and beta-blockers (metoprolol, carvedilol). Diuretics may also be needed.

In patients with symptoms more consistent with hypertrophic cardiomyopathy, beta-blocker therapy with propranolol or atenolol may be recommended. In NCCM patients with mitochondrial or metabolic causes, a "vitamin cocktail" might be added that includes coenzyme Q10, carnitine, riboflavin, and thiamine used alone or in combination.

If heart function is low, there is a greater chance for a blood clot to form in between the trabeculations, which can lead to stroke or other organ damage. An anticoagulant medication (aspirin, enoxaparin, warfarin) may be recommended to prevent blood clots.

Lifestyle changes, such as limiting physical activity and sports, may be necessary for some children. For those with an increased risk for sudden cardiac arrest, an implantable cardioverter-defibrillator (ICD) may be placed, or in some patients, a cardiac resynchronization therapy (CRT) device may be recommended. This involves implanting a combination pacemaker and ICD to coordinate the heart's pumping action and improve blood flow to the body. If heart function continues to weaken in spite of treatment, a mechanical pump or ventricular assist device (VAD) may need to be surgically inserted to help the heart pump and supply blood to the body. In advanced cases, a heart transplant may be necessary.

MAËLYS