

# PECTUS CARINATUM

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## Introduction and Definition

**Pectus Carinatum** (PC), commonly known as "pigeon chest" or "keel chest," is a structural anomaly of the anterior thoracic cage characterized by the abnormal, pronounced protrusion of the sternum and adjacent costal cartilages. This malformation of the chest wall results from an overgrowth or aberrant developmental pattern of the cartilage that articulates the ribs with the sternum, forcing the breastbone outward. This outward displacement results in a distinct, often pointed, convex appearance of the central chest, contrasting sharply with **Pectus Excavatum**, where the sternum retracts inward. While the condition is primarily morphological, its presence necessitates a thorough investigation, as it may serve as an indicator of underlying systemic disorders, particularly those affecting connective tissue integrity.

The anatomical presentation of Pectus Carinatum is typically classified into distinct subtypes based on the location and extent of the protrusion. The most prevalent form is the chondrogladiolar type, involving the lower aspect of the sternum (gladiolus) and the corresponding costal cartilages, resulting in a central, localized protrusion. Less commonly observed is the chondromanubrial type, which affects the upper sternum (manubrium) and often presents a more complex morphology, frequently associated with restrictive lung function or specific congenital syndromes. The degree of the deformity is highly variable among individuals, ranging from mild, barely noticeable prominence to severe, rigid protrusion that significantly alters the contour of the torso.

Although Pectus Carinatum is often initially categorized as a cosmetic concern, clinical assessment reveals that moderate to severe cases can impose subtle yet measurable biomechanical restrictions on thoracic movement. This restricted chest wall compliance can potentially reduce dynamic lung volumes and, in some instances, contribute to exercise intolerance or chronic fatigue, especially during periods of high physical demand. Furthermore, the profound psychosocial impact associated with living with a visible chest wall deformity often represents the most critical aspect of the patient's burden, frequently dictating the timing and type of intervention sought. A comprehensive clinical approach must therefore integrate precise anatomical correction with an evaluation of functional limitations and psychological support.

## Etiology and Pathogenesis

The precise etiology of Pectus Carinatum remains poorly understood, but current research suggests a complex interplay between genetic factors, intrinsic defects in cartilage metabolism, and mechanical forces exerted during skeletal development. A substantial proportion of cases exhibit a clear hereditary pattern, indicating a strong genetic predisposition, although the inheritance mechanism is generally considered polygenic rather than Mendelian. At a cellular level, the pathogenesis is linked to a localized defect in the growth regulation of the costal cartilages, leading to their excessive and asymmetrical proliferation. This overgrowth, constrained by the fixed

dimensions of the sternum and ribs, results in a mechanical buckling effect that forces the sternum anteriorly.

The association between Pectus Carinatum and systemic connective tissue disorders is well-documented, reinforcing the view that the chest wall deformity is sometimes a localized manifestation of a generalized mesenchymal defect. Notable conditions frequently linked to PC include **Marfan Syndrome**, **Ehlers-Danlos Syndrome**, and **Osteogenesis Imperfecta**, all of which involve faulty collagen or elastin synthesis, essential structural proteins within cartilage and connective tissues. Historically, nutritional disorders such as **Rickets** (Vitamin D deficiency) were primary acquired causes of Pectus Carinatum, as inadequate mineralization resulted in softened and structurally compromised costal cartilages that succumbed to internal pressures, though this etiology is less common in contemporary settings.

The timing of deformity progression is crucial to understanding its pathogenesis. While PC may be evident at birth, it often becomes significantly more pronounced during the rapid growth phase of adolescence, coinciding with hormonal surges that stimulate skeletal and cartilaginous growth. This accelerated development of the costal cartilages relative to the ossified sternum and ribs amplifies the outward vector of force, leading to a rapid increase in the degree of protrusion. Recognizing this growth dependency is fundamental for clinical management, as it informs the decision to initiate time-sensitive treatments such as external dynamic bracing, which relies on the continued plasticity of the adolescent cartilaginous skeleton for successful remodeling.

## Clinical Manifestations and Associated Conditions

The most salient clinical feature of Pectus Carinatum is the visual prominence of the sternum; however, a thorough clinical assessment must move beyond the cosmetic aspect to evaluate potential functional limitations. While many patients are asymptomatic regarding visceral function, some report non-specific symptoms such as mild dyspnea on exertion, reduced stamina, and chronic postural discomfort. These functional complaints are generally attributed to the reduced compliance and rigidity of the chest wall, which restricts the full excursion of the rib cage during deep inspiration, thereby increasing the work of breathing and potentially impacting exercise capacity.

Musculoskeletal comorbidities are frequently observed alongside Pectus Carinatum. Patients commonly develop compensatory postural habits, often exhibiting thoracic kyphosis (rounding of the upper back) or scoliosis (lateral curvature of the spine) as the body attempts to mask or counterbalance the anterior protrusion. Chronic back or chest pain may also arise from the abnormal mechanical stresses placed upon the spinal column and costochondral junctions. Furthermore, the psychosocial distress related to body image disturbance can manifest as physical symptoms, including palpitations or shortness of breath linked to anxiety, complicating the clinical

presentation.

The identification of associated systemic conditions is paramount in the management of Pectus Carinatum. The presence of PC should prompt screening for cardiac issues, especially mitral valve prolapse, which is commonly associated with generalized connective tissue disorders. When PC is identified in conjunction with genetic syndromes like **Marfan Syndrome**, the comprehensive care plan must address the risk of serious complications such as aortic dilation and dissection. Consequently, the clinical manifestation of Pectus Carinatum must be viewed not in isolation but as a potential gateway to diagnosing and managing broader, underlying pathological processes affecting multiple organ systems.

## Diagnostic Procedures

The diagnostic process for Pectus Carinatum begins with a comprehensive history and physical examination, during which the physician confirms the diagnosis visually, assesses the flexibility and symmetry of the chest wall, and screens for any functional limitations or signs of associated syndromes. Key aspects of the physical exam involve quantifying the degree of sternal protrusion and determining the precise anatomical subtype (chondrogladiolar vs. chondromanubrial). However, objective quantification and planning necessitate advanced imaging.

While a simple chest X-ray provides basic visualization of the skeletal alignment, the definitive imaging modality for quantifying the severity of Pectus Carinatum is **Computed Tomography (CT) scanning**. A low-dose CT scan, typically performed with the patient supine, yields detailed cross-sectional images essential for calculating objective measurements, such as the Carinatum Index, which measures the ratio of the chest width to the maximum anterior protrusion. This objective data is crucial for determining treatment suitability, particularly for surgical planning. However, given the concerns regarding pediatric radiation exposure, magnetic resonance imaging (MRI) is sometimes utilized as an alternative, offering excellent soft tissue resolution without ionizing radiation, though it may be less effective for routine bony measurements.

Beyond structural imaging, functional assessments are mandatory, especially prior to surgical consideration. **Pulmonary Function Tests (PFTs)**, including spirometry and exercise tolerance tests, help quantify any restrictive ventilatory defect, establishing a functional baseline. Furthermore, an **Echocardiogram** is essential to rule out cardiac compression or associated valvular anomalies. For example, the presence of **mitral valve prolapse** might suggest an underlying connective tissue disorder, guiding further genetic testing and specialized follow-up. The synthesis of these structural, functional, and systemic diagnostic inputs ensures that the resulting treatment plan is maximally informed and addresses all facets of the patient's health.

## Psychological and Social Impact

For many individuals, particularly adolescents, the most debilitating consequence of Pectus Carinatum is not physical but psychological. The visible nature of the protruding chest wall often leads to significant self-consciousness, shame, and distress regarding body image. This emotional burden is magnified during early puberty, a period characterized by heightened social comparison and fixation on physical appearance. The resulting self-perception of being flawed or abnormal frequently triggers avoidance behaviors, such as refusing to expose the torso in public settings, withdrawing from team sports, and adopting permanently concealing clothing styles.

The social ramifications of this body image disturbance can be severe, contributing to social isolation and reduced quality of life. Peer ridicule or bullying, whether subtle or overt, can further erode self-esteem and contribute to the development of serious mental health issues, including social anxiety, clinical depression, and body dysmorphic disorder. The patient's perception of the deformity often outweighs the actual measured severity, highlighting the necessity of prioritizing psychological well-being in the treatment planning process.

Consequently, expert psychological screening and support are indispensable components of Pectus Carinatum management. Counseling helps patients process the emotional impact, develop coping mechanisms, and manage expectations regarding treatment outcomes, whether non-surgical bracing or operative repair. Effective communication within the multidisciplinary team--involving surgeons, orthopedists, and mental health professionals--is crucial to ensure that the pursuit of anatomical correction directly translates into a significant and lasting improvement in the patient's self-confidence and overall psychosocial functioning.

## Non-Surgical Treatment Modalities

Non-surgical management, primarily utilizing external dynamic compression bracing, represents the first-line treatment for Pectus Carinatum in patients whose skeletal structure remains pliable, typically prepubescent or early adolescent individuals. The mechanism relies on applying continuous, gradually increasing external pressure directly to the protruding cartilages and sternum, leveraging the plasticity of the adolescent skeleton to reshape the chest wall over time. This targeted pressure encourages the remodeling and controlled regression of the hyperplastic costal cartilages.

The success of dynamic bracing is critically dependent on two factors: the patient's skeletal maturity and their compliance with the treatment regimen. Braces are custom-fabricated devices designed to maximize comfort while maintaining high corrective force, often requiring wear for 18 to 24 hours per day. Treatment duration is highly variable, typically spanning six months to two years, and requires rigorous adherence. Bracing effectiveness diminishes significantly once the patient reaches skeletal maturity, characterized by the fusion of growth plates, as the chest wall

becomes rigid and resistant to external forces.

Advantages of bracing include its non-invasiveness, avoidance of surgical risks, and lower overall cost. However, challenges relate primarily to maintaining high compliance, especially among self-conscious teenagers, and managing minor local complications such as skin irritation or pressure sores, which necessitate frequent clinical adjustments. Regular follow-up, often involving quantitative measurement of the protrusion index via ultrasound or low-dose imaging, is essential to confirm progressive correction and motivate the patient throughout the long course of therapy.

## Surgical Intervention Strategies

Surgical correction is indicated for severe or rigid Pectus Carinatum cases, for patients who have completed skeletal growth, or for those who have failed non-surgical bracing. The objective of surgery is the permanent normalization of the chest wall contour and the removal of potential mechanical restrictions. The traditional and most widely accepted operative technique is the modified **Ravitch procedure**, an open surgical approach. This method involves a transverse incision, subperichondrial resection of the excessively long and deformed costal cartilages, mobilization of the sternum, and a corrective sternal osteotomy to flatten the sternum. The repositioned sternum is then stabilized, often temporarily using internal wire fixation or synthetic mesh until healing occurs.

In contrast to the cartilage-resecting Ravitch technique, some centers employ a minimally invasive approach, often referred to as the **Reverse Nuss procedure**. This technique, adapted from the common repair for Pectus Excavatum, involves introducing a highly specialized, custom-bent metal bar across the internal chest wall. The bar is rotated to exert sustained inward pressure against the protruding sternum, physically pushing it into a normalized position. This minimally invasive method minimizes extensive scarring and large cartilage excisions but is highly dependent on precise bar placement and patient selection, typically being most effective for specific symmetrical morphologies.

Surgical correction, regardless of the technique, is a major undertaking that demands careful pre-operative planning, including detailed imaging and functional assessments. While complications such as infection, pneumothorax, or recurrence are possible, modern surgical outcomes are generally excellent, providing significant and lasting aesthetic correction. The substantial improvement in body image and quality of life following successful surgical repair often justifies the procedure, particularly for individuals who have endured years of psychosocial distress due to the prominence of their condition.

## Prognosis and Long-Term Management

The overall prognosis for individuals diagnosed with Pectus Carinatum is highly favorable, largely

due to the effectiveness of both contemporary bracing and surgical techniques. When non-surgical bracing is initiated early in the patient's growth phase, the likelihood of achieving near-total, permanent correction is high, eliminating the need for invasive procedures. For patients requiring surgery, the long-term stability of the repair is robust, with low rates of significant recurrence once the sternum has healed in its new, corrected position.

Long-term management focuses on monitoring the structural integrity of the chest wall, promoting healthy posture, and encouraging full participation in physical activities. Post-correction, many patients report subjective improvements in exercise capacity and reduced fatigue, confirming the functional benefits of the anatomical repair. Regular, albeit infrequent, follow-up is necessary for those who have undergone surgical repair to monitor the status of any implanted bars or internal stabilization devices, which are typically removed after two to three years.

Crucially, long-term care must also address any underlying associated conditions. Patients with identified connective tissue disorders must continue specialized monitoring with relevant specialists, such as cardiologists or geneticists, independent of the successful chest wall repair. Ultimately, the successful management of Pectus Carinatum involves not just fixing the anatomical defect but ensuring the patient achieves full psychological recovery and integration. The clinical identification of the condition, as exemplified by the statement, "The doctors have identified Matt's condition as being **pectus carinatum**," marks the essential starting point for a comprehensive, multidisciplinary care strategy aimed at restoring both form and function.