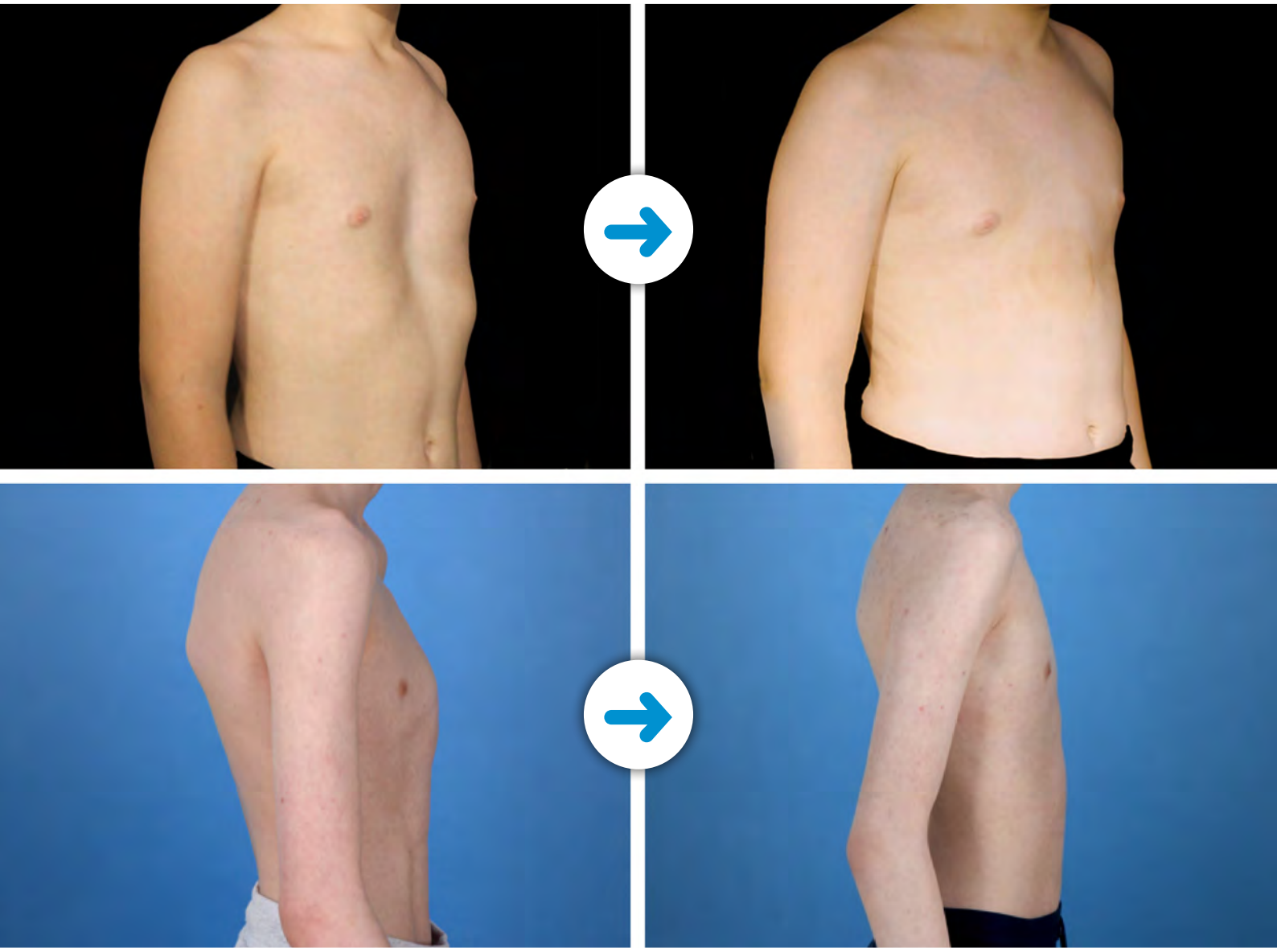
The British Association of Prosthetics and Orthotics



A guide to the conservative management of pectus carinatum and pectus excavatum

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Endorsed by Pectus Matters

PECTUS MATTERS

This professional guide to bracing pectus carinatum and vacuum bells for pectus excavatum is a major step forward to help all young people who are affected, as well as their families.

Whilst conditions affecting other parts of the body (such as the skull, the face, the limbs) receive prompt attention, the pectus conditions are downplayed and often ignored, partly because people can conceal their chest wall difference beneath clothing and because the public and health professionals are largely unaware of the negative effects of pectus conditions.

Such impacts are obscure and cannot be easily measured, such as the negative psychological impact, often at such a critical stage of emotional, social, physical, and educational development. In more severe pectus excavatum, there may also be associated cardiopulmonary symptoms due to compression of the lungs, heart, and major vessels.

The lack of early conservative treatment has allowed some pectus conditions to progress and become so severe that only major surgery is possible as a treatment option, with all of its associated risks.

This guide by BAPO is representative of the new hope for young people with pectus - that low-risk conservative bracing might greatly relieve their condition, diminish the associated negative impacts, and avoid the potential need for surgery. The United Kingdom needs a structured pectus care pathway that gives equal access to conservative treatment for all young people with the condition - 'Bells and Braces' - and this guide will be the foundation for that pathway.

Thank you BAPO. This is exemplary work. As a charity, Pectus Matters is most appreciative of all you are doing and the many dedicated orthotists and allied health professionals who are making a positive difference for people with pectus.

Simon Kendall
Chair, Pectus Matters

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Executive summary

Pectus carinatum and pectus excavatum are among the most common congenital chest wall deformities, with the potential to affect not only physical function but also body image, self-confidence, and psychological well-being, particularly during adolescence. Conservative management, including orthotic bracing for pectus carinatum and vacuum bell therapy for pectus excavatum, has become an established part of care alongside surgical pathways, delivered by multidisciplinary teams that may include orthotics, physiotherapy, psychology, respiratory medicine, surgery, specialist nursing and patient support organisations.

Despite the growing use of conservative treatment approaches, there is variation across the United Kingdom in how patients are triaged, assessed, managed, and monitored, and in the level of access to specialist chest wall services. This document addresses this variation by providing practical, evidence-informed guidance for orthotists and the wider multidisciplinary team.

Key areas covered include triage and referral pathways, the composition and role of the multidisciplinary team, clinical assessment of chest wall flexibility and severity, orthotic protocols for pectus carinatum bracing, vacuum bell therapy for pectus excavatum, monitoring and outcome measurement, and risks and complications associated with conservative treatment. The guide also highlights red flag features, such as suspected connective tissue disorders, scoliosis, or significant cardiopulmonary symptoms, which warrant prompt referral for specialist multidisciplinary review.

This guide was developed by orthotists in collaboration with a multidisciplinary team and the charity Pectus Matters, drawing on the lived experience of patients and families alongside the available clinical evidence. It is intended to support more consistent, equitable, and evidence-informed care for children and young people affected by pectus deformities across the United Kingdom.

Dr Nicky Eddison
Chair, BAPO

“This guide is an important step forward for pectus care. Earlier assessment and wider access to effective treatments such as bracing and vacuum bell therapy can improve outcomes for many young people and prevent the need for surgery. I very much hope it will help to make high-quality conservative treatment more available to patients.”

Mr Aman S Coonar
Consultant Thoracic Surgeon, Royal Papworth Hospital, Cambridge, UK, NHS National Clinical Lead for Thoracic Surgery, President, Society for Cardiothoracic Surgery

Scope and Purpose

This guide provides recommendations for the assessment and conservative management of pectus carinatum and pectus excavatum in children and young people* within orthotic services and multidisciplinary chest wall services. It aims to support clinical decision-making, promote evidence-informed practice, and encourage greater consistency in care across different services. It is intended for orthotists and members of specialist chest wall multidisciplinary teams working within publicly funded and independent services across the United Kingdom.

*In this guide, "children and young people" refers to people under 18 years of age

1 Background and Rationale

Pectus deformities are among the most common congenital abnormalities of the anterior chest wall. Pectus excavatum is generally regarded as the most common form, with reported incidence of up to 8 per 1000 live births, whereas pectus carinatum is reported to occur two to four times less frequently, with an estimated incidence of approximately 1 per 2,500 live births.[1] However, epidemiological estimates vary considerably. Population-based studies have reported pectus excavatum prevalence ranging from approximately 0.4% to 1.3%, pectus carinatum prevalence from approximately 0.3% to 0.7%, and an overall prevalence of pectus deformities
of approximately 1% to 2%.[2-4] This variation is likely to reflect differences in the populations studied, participants' ages, diagnostic criteria, screening methods and the inclusion of mild phenotypes.

Although historically considered primarily cosmetic conditions, both pectus carinatum and pectus excavatum are increasingly recognised as having potential physical and psychosocial impacts. Patients may experience pain, exercise intolerance, postural concerns, body image disturbance, reduced self-confidence, and social anxiety, particularly during periods of rapid growth and adolescence. Increasing awareness of these impacts has led to greater recognition of the importance of timely assessment and access to specialist management pathways.

In recent years, conservative management of pectus deformities has evolved significantly, with increasing utilisation of orthotic treatment, physiotherapy, exercise-based interventions, and multidisciplinary care models. Specialist pectus services have demonstrated the value of coordinated multidisciplinary assessments involving orthotics, physiotherapy, psychology, respiratory medicine, surgery, specialist nursing, and patient support organisations. However, despite the growing use of conservative treatment approaches, there remains significant variation in assessment, patient selection, orthotic management, follow-up protocols, outcome measurement, and access to specialist services across the United Kingdom.

Therefore, this guide was developed to support a more consistent, evidence-informed approach to the conservative management of pectus deformities. This document aims to provide practical guidance for orthotists and multidisciplinary teams involved in pectus care, promote equitable access to appropriate

treatment pathways, and encourage greater standardisation of clinical practice. The guide was developed collaboratively by clinicians from multidisciplinary pectus services and patient representatives, including Pectus Matters.

"Pectus deformities affect far more than the shape of the chest. For many young people, they affect confidence, body image and participation in everyday life. Appropriate non-surgical treatment with vacuum bell therapy or dynamic bracing can provide excellent outcomes, helping many patients avoid surgery while restoring confidence and quality of life."

Mr Olugbenga Michael Aworanti,
Consultant Paediatric Surgeon, Leeds Children's Hospital

2 Triaging

Patients referred from primary care to a local chest wall service are typically triaged by paediatric surgery, paediatric thoracic surgery or cardiothoracic services, although some pathways allow referral to orthotic services as the first point of assessment, depending on local service configuration.

Initial triage should be undertaken by an appropriately experienced clinician, usually a consultant surgeon or a designated member of the specialist chest wall team. This clinician may be an orthotist. Following the initial triage, patients should proceed through the agreed local pathway. Service models may vary between centres depending on staffing, expertise, and patient numbers. For example, some services may utilise physiotherapy-led pathways for pectus excavatum assessment, while others may involve orthotists more directly within the triage and assessment process.

In some NHS Trusts/Health Boards, orthotic services are the initial point of contact for patients with suspected pectus carinatum. Where this model is utilised, it should be supported by clearly defined local governance arrangements and referral pathways. Services should ensure appropriate screening for associated conditions and onward referral mechanisms for patients presenting with suspected connective tissue disorders, hypermobility syndromes, scoliosis, or other relevant comorbidities that require multidisciplinary assessment or specialist input.

3 Referral Pathways and MDT Involvement

Management of pectus deformities should be delivered within clearly defined local or national referral pathways with access to appropriate multidisciplinary team (MDT) support. Service configuration may vary between centres and across the four nations; however, pathways should ensure timely assessment, appropriate escalation, and access to specialist opinion where required.

Orthotic management does not preclude future surgical review. Patients demonstrating poor response to conservative treatment, significant physiological compromise, progressive deformity, complex comorbidity, or significant psychosocial impact should be discussed within an MDT setting and referred for specialist surgical opinion, where appropriate.

3.1 Pectus Carinatum Referral Pathway

In many centres, patients with suspected pectus carinatum may be referred directly from primary care to orthotic services following an agreement with the local paediatric surgery or thoracic service. This model may improve access to conservative treatments and reduce delays in assessment. Some services also accept referrals from other Allied Health Professionals (AHPs) and self-referrals only where this is permitted by a clearly defined local pathway and the patient is already known to the service.

A typical pathway may include the following:

- GP or primary care referral following identification of anterior chest wall prominence
- Initial screening for associated conditions or syndromic features where clinically indicated
- Orthotic assessment and provision of chest compression orthosis where appropriate
- Ongoing review and treatment monitoring within the orthotic service
- Re-referral to surgical or specialist services if treatment is unsuccessful, concerns arise during treatment, or significant progression occurs

Services utilising direct referral to orthotics should have clearly defined governance arrangements and escalation pathways in place with the supporting surgical team.

3.2 Pectus Excavatum Referral Pathway

As pectus excavatum may be associated with physiological symptoms and surgical management pathways remain available in selected cases, assessment by paediatric surgery, thoracic surgery or a specialist chest wall service is required before conservative treatment is initiated.

A typical pathway may include the following:

- GP or primary care referral following identification of a chest wall difference or associated symptoms
- Assessment within paediatric surgery, thoracic surgery, or specialist chest wall service
- Screening for associated conditions or syndromic features where clinically indicated
- Consideration of conservative treatment options such as vacuum bell therapy and physiotherapy
- MDT discussion and further investigation for patients with significant functional limitation, complex deformity, or consideration for surgical intervention

“As a surgeon, it is equally important to know when not to operate. The shape of the chest wall can impact children and young people significantly, and having the ability to address this without the risks of surgery is invaluable.”

Michael Jacovides, Consultant Paediatric Surgeon

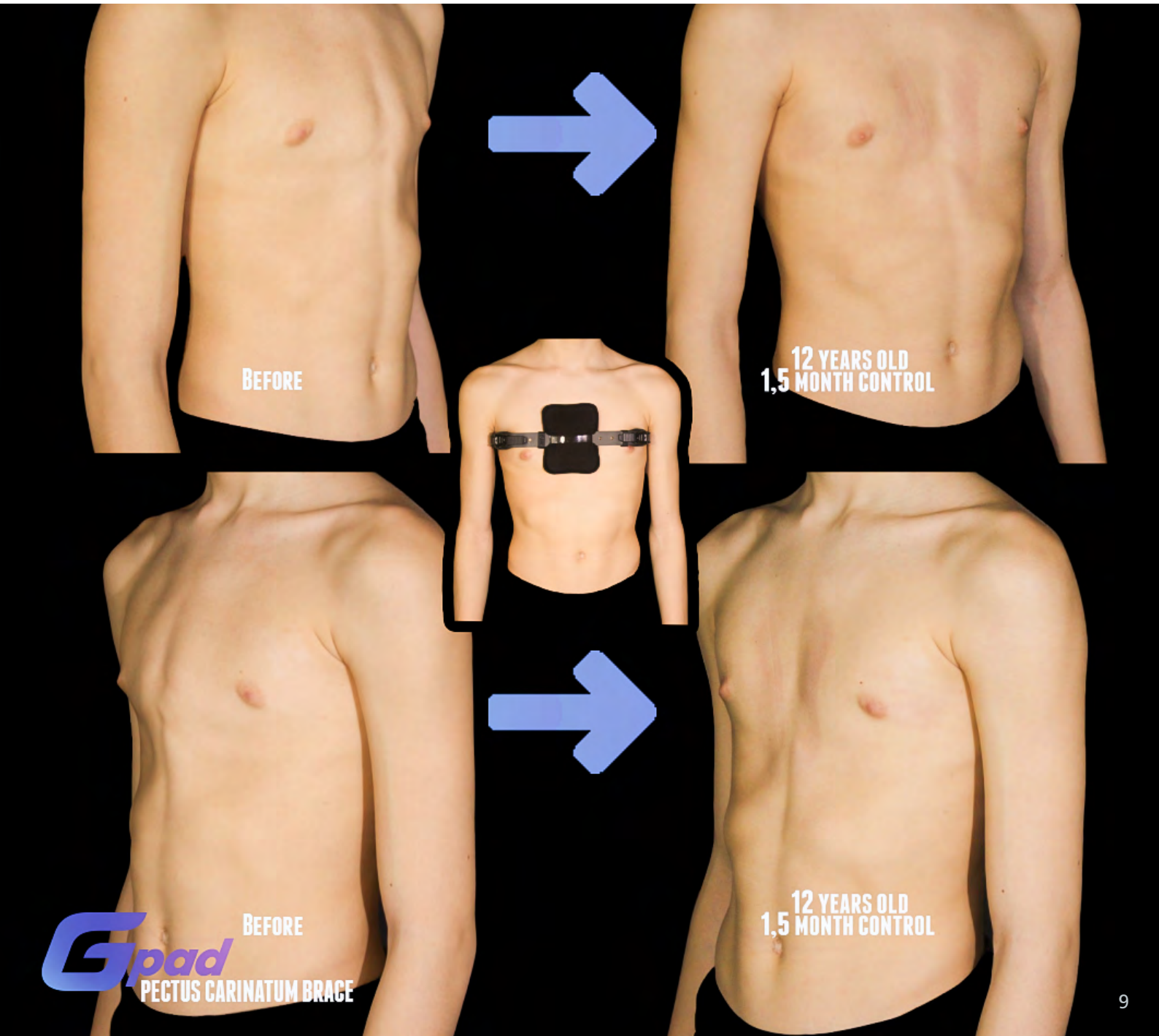
4 Red Flags and Associated Conditions

Services should have clear pathways for the identification and onward referral of patients presenting with features suggestive of associated conditions or complex pathology.

Red flags may include:

- Scoliosis
- Hypermobility syndromes
- Suspected connective tissue disorders including Marfan syndrome
- Significant cardiopulmonary symptoms, including exertional breathlessness, chest pain, palpitations or fainting
- Rapid progression of deformity
- Complex pain presentation
- Significant psychological distress

Referral pathways should support timely access to appropriate specialist services, including genetics, cardiology, respiratory medicine, specialist paediatric spinal services, physiotherapy, psychology, and surgery, where indicated.



5 Multidisciplinary Team

Pectus conditions benefit from support from a wider multidisciplinary team when possible. Each chest wall service will have access to different team members. The following health professionals may be involved in the treatment of pectus conditions.

Anaesthetist
A medical doctor who supports the patient if they are listed for surgery. The anaesthetist will ensure that the patient is safe and comfortable in the immediate preoperative, intraoperative, and postoperative environments.

Cardiologist
Assesses patients with suspected cardiac involvement or features of a connective tissue disorder and arranges appropriate cardiac investigations.

Cardiothoracic surgeon
A medical doctor specialising in surgery of the chest, heart and lungs. They assess patients being considered for surgical correction of pectus deformities, particularly pectus excavatum, and review the effect of the condition on the structures within the chest. They discuss surgical options, expected outcomes and potential risks, request any necessary investigations, and provide care before, during and after surgery.

Clinical genetics service
Assesses patients with suspected inherited connective tissue disorders and advises on genetic testing.

Clinical psychologist
The clinical psychologist assesses and supports the psychological and behavioural effects associated with the condition and its treatment. They may be able to offer therapy that will help mitigate the impact of pectus conditions on self-esteem, body image, confidence, and general mental health.

Medical illustration
A specialist team captures two-dimensional and three-dimensional images to document the clinical presentation. This is useful for monitoring changes in chest shape over time.

Nurse specialist
An advanced practice nurse supports the treatment pathway with expert clinical knowledge and leadership. They usually work across the entire treatment pathway, engaging with all key stakeholders and supporting the patient's treatment journey.

Orthopaedic surgeon / Paediatric orthopaedic surgeon
The orthopaedic surgeon assesses and manages associated musculoskeletal conditions that may influence the presentation or treatment of a pectus deformity. This may include scoliosis, spinal deformity, postural asymmetry or other orthopaedic conditions. They may arrange further investigations where required, advise on management of associated musculoskeletal problems and contribute to multidisciplinary decision-making where these conditions may affect the pectus treatment pathway.

Orthotist
Orthotists are allied health professionals who specialise in medical devices and biomechanics. They usually lead the assessment, measurement, fitting, and monitoring of the chest compression orthosis for pectus carinatum and may contribute to vacuum bell treatment for pectus excavatum where this is within local scope of practice.

Paediatric surgeon
This is the medical lead for many chest wall services, although some are AHP-led. The surgeon leads the surgical pathway for pectus excavatum. The surgeon assesses patients from a medical perspective and arranges any investigations required to determine whether treatment is safe and appropriate.

Pain team
In cases of chronic pain, which may occur before or after surgery and is more common for pectus excavatum than for carinatum, the pain team will coordinate a specialist multidisciplinary approach to manage pain and improve quality of life.

Physiotherapist
The physiotherapist will work with the young person to support postural improvement, strengthening and appropriate physical activity. They also work on breathing mechanics to improve lung function. In some locations, they will lead the assessment, fitting, and monitoring of vacuum bells for pectus excavatum.

Respiratory clinical scientist
This specialist manages the physiological assessment of lung diseases and may undertake testing to assess the lung function of patients with pectus excavatum to understand the impact of the condition on their lung capacity and function.

Specialist spinal service
Assesses and monitors patients with suspected scoliosis or another spinal deformity.

"As a surgeon who has more than 16 years of experience in the assessment and treatment of children and young people with pectus deformities, I welcome this BAPO guide as a significant milestone in the care of patients with pectus carinatum and pectus excavatum. Until now, there has been no standardised pathway for the diagnosis, assessment, and management of these conditions, often leaving children, young people and their families struggling to access timely advice and appropriate treatment. This guide provides much-needed direction for patients, parents, healthcare professionals and orthotic specialists, helping to establish a consistent and evidence-based approach to care.

Pectus deformities can have a profound impact on the physical, psychological and social well-being of young people. Many experience exercise limitation, reduced self-confidence and significant embarrassment about their appearance. Peer pressure, social anxiety, and bullying can further compound their distress, often leading them to withdraw from sports, avoid social activities and alter their lifestyle at a critical stage of development. Because these conditions are relatively uncommon, patients frequently face delays in diagnosis and referral, missing valuable opportunities for early intervention and reassurance.

Early recognition and timely referral to specialist services are essential. While pectus deformities can present at any age, they are most commonly identified during adolescence, a period when non-invasive treatments are most effective. In our experience, beginning treatment from around 12 years of age and throughout the early teenage years offers the greatest opportunity for successful correction. The majority of pectus carinatum deformities can be effectively treated with external bracing, avoiding the need for surgery altogether. Similarly, although the success rates of vacuum bell therapy for pectus excavatum are lower than those achieved with bracing for pectus carinatum, almost half of appropriately selected patients can achieve satisfactory improvement and avoid the risks and potential complications associated with surgical correction, such as the Nuss procedure.

It is therefore vital that children and young people with pectus deformities are referred early to specialist teams who can provide reassurance, guidance on exercise and lifestyle, and access to appropriate brace or vacuum bell therapy. This excellent guide from BAPO represents an important step towards improving awareness, standardising care and establishing the dedicated pectus pathways that patients and families have long needed. It will serve as an invaluable resource for healthcare professionals and families alike, helping to ensure that more young people receive the right treatment at the right time and achieve the best possible outcomes."

Mr Ram Dhannapuneni, Consultant Congenital Cardiac and Pectus Surgeon
Specialist in the management of pectus deformities in children and young people

6 Clinical Assessment

The patient will have been referred to the orthotic service via the routes described earlier. Appropriate triage should be completed to ensure that the patient has followed the correct pathway, and the patient should be referred to a specialist chest wall service if this has not already occurred. This is particularly important for pectus excavatum, which may have physiological implications.

An initial information-gathering appointment may take place by video or in person. Chest wall flexibility, spinal screening and definitive physical assessment require an in-person appointment. A virtual appointment can be useful to gain an understanding of the severity of the condition and the patient's understanding, readiness and willingness to undertake treatment, especially where families are travelling large distances, and may be useful to manage expectations of treatment and potential outcomes.

A detailed discussion should be held regarding bracing to ensure that the patient fully understands the demands of treatment and the expectations around brace wear. The patient should be shown a brace and given the opportunity to handle it, allowing them to make a more informed decision about proceeding with treatment.

If they wish to undertake orthotic management of their pectus condition, they must be offered a face-to-face appointment. Appointments should be planned and timed as outlined in the **BAPO standards and best-practice guide**.

The assessment should be comprehensive and holistic, incorporating the physical, functional, and psychological domains.

The initial assessment is similar for pectus carinatum and pectus excavatum. Condition-specific assessment is outlined in Sections 6.1 and 9.

Initial Assessment

Key components include:

- Age and pubertal status: this allows an initial understanding of growth potential. This is particularly relevant when planning brace design before breast development. Assessment and treatment must be individualised and discussed sensitively.
- Family history of chest wall deformity, connective tissue disorder or scoliosis
- Screening for syndromic features (e.g. Marfan phenotype, Beighton score). If there are signs of Marfan syndrome or another connective tissue disorder, refer the patient to their GP or the relevant specialist service for further assessment if this has not already been completed
- Spinal assessment, including scoliosis screening. There is an increased risk of scoliosis in association with pectus conditions.[5,6] If scoliosis is noted on the Adams forward bend test, a referral should be made to the local specialist paediatric spinal surgery team for monitoring and treatment as required.
- Presence of pain, dyspnoea, or activity limitation
- Patient-reported perception of appearance and quality of life
- Changes in appearance may be associated with social withdrawal or reluctance to participate in activities such as swimming
- Clinical photography and surface scans can be useful for monitoring pectus conditions. These can be completed in the clinic after documented consent has been obtained in accordance with the relevant local clinical photography policy, and images saved in the patient notes in accordance with local information governance and clinical photography policies. Patients can also be referred to clinical photography for monitoring

6.1 Pectus carinatum-specific assessment

Pectus carinatum has several clinical presentations.

6.1.1 Chondrogladiolar prominence

A central deformity in which the inferior aspect of the sternum is prominent. It is usually flexible and responds well to orthotic management.

6.1.2 Lateral pectus carinatum

A lateral pectus carinatum deformity in which rotation of the sternum produces unilateral prominence. It is usually flexible and responds well to orthotic management.

6.1.3 Chondromanubrial prominence and pectus arcuatum

Chondromanubrial pectus carinatum involves prominence of the upper sternum and is usually stiff and less responsive to bracing. Pectus arcuatum is a complex presentation with upper sternal prominence and lower sternal depression and should be referred for specialist assessment.

Symmetry

The chest shape can be symmetrical or asymmetrical. Asymmetry may cause the brace to rotate, reducing initial comfort and potentially affecting adherence. However, this has not been linked to reduced success in orthotic treatment.[7]

Flexibility

Chest wall stiffness varies between patients, which can change over time with maturity and throughout treatment. Chest wall stiffness will be assessed during the initial appointment. Suitability for bracing should be determined using an evidence-based pressure-of-correction or force-of-correction protocol. The measurement unit, threshold and device must match the cited evidence; newtons and psi are not directly interchangeable. Where the measured force of correction is between 100 and 120 N, the patient may be offered a time-limited trial of bracing following appropriate counselling. It should be explained that a higher initial force of correction may be associated with a longer treatment duration and a reduced likelihood of complete correction. Outcomes will also depend on the height, morphology and flexibility of the deformity, the patient's adherence to treatment and the chest wall's early response to bracing.[8-10]

If a validated measurement device is unavailable, record flexibility using a standardised manual assessment. Place one hand on the patient's back and the other over the prominence, then apply firm, controlled pressure using the same technique at every assessment.

Stiff: no visible correction with firm, controlled manual pressure.

Moderately flexible: partial correction with firm, controlled manual pressure.

Flexible: full correction with firm, controlled manual pressure.

Severity

Assessment of pectus deformities should consider the patient's symptoms, clinical presentation, imaging findings and physiological impact, alongside relevant radiological indices. In pectus excavatum, the conventional Haller index is an internal CT-based measurement that may form part of this wider assessment. It is not routinely used for pectus carinatum, where external chest wall measurements or three-dimensional surface scanning may instead be used to document the shape and severity of the deformity and monitor changes over time.

However, the impact of severity on the affected individual is subjective, and the opinion of the individual should be considered when deciding whether to offer treatment. Use a patient-reported rating of satisfaction with chest shape on a 0 to 5 scale, where 0 means very dissatisfied and 5 means very satisfied.

7 Management of Pectus Carinatum

The primary treatment for flexible pectus carinatum in children and adolescents is external chest compression bracing. Orthoses apply sustained corrective pressure to the sternum, promoting gradual remodelling of the costal cartilages during growth.

Treatment success is greatest in patients with flexible deformities. Increased severity and stiffness are associated with longer treatment duration and a lower likelihood of full correction.

7.1 Orthotic management of pectus carinatum

There are several custom-made and off-the-shelf pectus carinatum braces. All of these work according to the same principle of applying pressure over the chest wall prominence with anterior and posterior pads attached to the brace. The pads must be firm enough to apply pressure while having an interface that conforms to the shape of the chest, preventing pressure issues to the skin and soft tissues.

The pads are attached to an external frame which is fastened at the side, allowing the patient to control the tightness of the brace and apply a comfortable amount of pressure so that the brace self-suspends and a corrective force pattern is applied.

Because the brace applies anterior-posterior compression, its lateral aspects must remain clear of the chest wall to allow comfortable chest expansion during breathing.

7.2 Surgical treatment

In England, surgery for pectus carinatum is not routinely commissioned. Patients with severe or complex deformity should be referred through the appropriate specialist pathway for individual assessment.

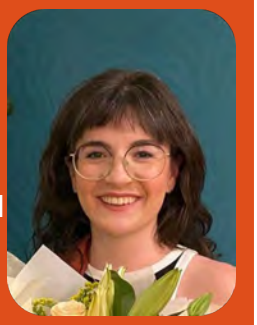
Surgical services and eligibility criteria vary across Scotland, Wales, and Northern Ireland. Patients should be referred according to current national and local pathways.

Abramson procedure or reverse Nuss procedure
Minimally invasive surgery, where a metal bar is inserted into the chest wall and placed over the sternum to flatten a prominent sternum. The procedure is performed through two small incisions. Any temporary support bar is removed after the period specified by the surgical team.

Ravitch
An open surgery in which the costal cartilage and sternum are reshaped. This is often supported by the addition of a temporary support bar or mesh. Where a temporary support bar is used, it is usually removed after the period specified by the surgical team.

In Scotland, patients selected for surgery are assessed by a clinical psychologist to identify psychological needs and provide appropriate preparation and support.

Under the right circumstances, surgery is invaluable for improving the quality of life in this patient population. However, conservative management can avoid unnecessary risk and anxiety for patients, whilst preserving similar treatment benefits. It can also be more tolerable for patients from neurodivergent backgrounds.



Dr Sarah Adam, Scottish National Chest Wall Service & Haematology Oncology, Paediatric Psychology, Royal Hospital for Children, Glasgow

8 Orthotic Pectus Carinatum Treatment Protocols

8.1 Assessment

Chest wall flexibility should be assessed using the validated measurement device and protocol adopted by the service. The device, measurement unit and threshold must match the supporting evidence. Where the service uses a validated newton-based protocol, patients requiring more than 120 N should not be offered a pectus carinatum orthosis under that protocol. Patients requiring 100 to 120 N may be offered a time-limited trial following counselling. These thresholds must not be inferred by converting values reported in psi. Centres measuring pressure in psi must be aware that bracing should not be offered if Pressure of Initial Correction (PIC) exceeds 10 psi.

Where available and with documented consent, standardised clinical photographs, including images obtained by medical illustration where available, and three-dimensional surface scans, should be obtained at baseline to document chest shape. Repeat imaging should be obtained when a clinically observable change needs to be documented.

Off-the-shelf orthoses are useful in the majority of cases, especially for symmetrical, moderate pectus carinatum. In cases of significant asymmetry or atypical presentation, a custom-made orthosis is more appropriate.

For patients who are likely to develop breasts, earlier assessment may make brace design and fitting easier. Treatment timing must be individualised and discussed sensitively with the patient and family.

8.2 Fitting

Two principal protocols are commonly employed:

The Calgary protocol recommends a gradual increase in brace wear over the first week, progressing to up to 23 hours per day during the correction phase, although 16–20 hours per day may be prescribed according to individual tolerance and clinical requirements. Once correction has been achieved and remains stable throughout the day, brace wear may be reduced to night-time use as part of the maintenance phase.[11]

Intensive protocol: Intensive bracing protocols prescribe near-continuous brace wear, typically for up to 23 hours per day during the correction phase, with removal for personal hygiene, physical activity and skin inspection. Regular clinical review is required to monitor skin integrity, brace pressure and treatment response. This approach is generally suitable only for patients with a flexible, compressible chest wall and is not recommended where the deformity is rigid or cannot be corrected through external compression.[12,13]

8.3 Review

At each clinic review, chest wall flexibility should be reassessed and wear-time data should be downloaded where a compatible logger is used. This information will be used to support ongoing discussions with patients regarding treatment progress and future expectations.

Video appointments may be used between face-to-face reviews every six months to discuss progress and address minor issues. Patients and parents can be guided through minor fitting adjustments, and additional padding can be sent where clinically appropriate. This approach is particularly effective for services with a national or geographically dispersed patient population.

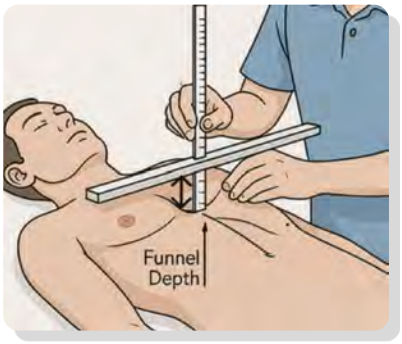
8.4 Discharge

Following correction, patients should enter a defined maintenance phase and continue periodic review until skeletal maturity or until the clinical team determines that recurrence risk is low. Review frequency should be individualised according to age, growth, chest wall flexibility and recurrence risk. Discharge should occur when growth is substantially complete, correction remains stable without intensive brace wear and a clear self-referral pathway has been provided. If the individual is younger than 18 years at this time, they will be informed that they can self-refer back to the service should they have any concerns about recurrence. Patients are encouraged to inform the service of any recurrence, whether they wish to receive treatment for it or not.

9 Orthotic Management of Pectus Excavatum

Vacuum bell therapy is an established non-surgical option for selected patients with pectus excavatum. The device creates negative pressure, encouraging anterior displacement of the sternum over time. Severity is measured using the Haller index, which is determined using CT.

Funnel depth is used to track improvements. Funnel depth does not necessarily correlate with the degree of cardiopulmonary impairment. With the patient supine, place a rigid straight edge across the chest and measure vertically from the straight edge to the deepest point of the depression.



Use the same patient position, anatomical reference points and measuring device at every review to provide a reproducible measure of response to treatment. This value may change after a growth spurt.

Generally, the size of the vacuum bell is determined by:
1 Height of patient
2 Width between nipples
3 Visual assessment of the patient

The vacuum bell model, suction level and wearing schedule must be individually prescribed by the specialist team and used in accordance with the manufacturer's instructions. Treatment must not be initiated using a generic suction setting or wearing schedule. A full orthotic assessment should include the physical, functional and psychological effects of pectus excavatum.

Application guide for the Vacuum Bell
1 Position the patient supine for the first application. Some patients may feel faint initially. Subsequent applications may be completed in another safe position once the patient is confident.
2 Select a vacuum bell large enough for its rim to rest on the chest wall outside the depression.
3 Place the vacuum bell over the centre of the depression.
4 Apply gentle pressure to the front of the vacuum bell to create a seal.
5 Apply suction gradually until the chest wall rises. The patient should feel pressure but must not experience pain.
6 Ask the patient to sit up and confirm that the vacuum bell remains securely in place.
7 Practise donning and doffing with the patient sitting upright, the trunk straight and the shoulders gently retracted. Incorrect positioning may prevent an effective seal.

Suitable candidates are commonly younger patients with a flexible, mild to moderate and predominantly symmetrical deformity. Selection must be individualised by the specialist team; do not use a fixed age or 25 mm funnel-depth threshold unless it is supported by a cited protocol. Older teenagers may also respond, although a longer treatment period and sustained adherence may be required.

It is important that these patients are seen by the thoracic surgery team because pectus excavatum may be associated with cardiopulmonary symptoms or underlying conditions that require specialist assessment. In addition, certain conditions must be ruled out to ensure the safe use of the vacuum bell.

9.1 Contraindications

Vacuum bell therapy should not be started until a specialist clinician has reviewed potential contraindications.
1 Skeletal disorders that reduce bone stability, including osteogenesis imperfecta or clinically significant osteoporosis.
2 Uninvestigated cardiovascular or vascular disease, including suspected aortic aneurysm or aortopathy (disease of the aorta, including dilation). Marfan syndrome is not itself a simple absolute contraindication. Patients with suspected or confirmed Marfan syndrome require specialist cardiovascular assessment before vacuum bell therapy is considered.
3 Bleeding disorders, including thrombocytopenia or haemophilia, or clinically significant anticoagulant treatment.

Depending on the severity of symptoms and diagnosis, patients with symptoms, significant deformity or possible surgical indications should be referred to the relevant specialist chest wall MDT for assessment.

10 Monitoring and Outcome Measures

The outcome of vacuum bell therapy should not be assessed using funnel depth alone. Some patients may experience meaningful improvements in symptoms or physical function without perceiving a comparable improvement in chest appearance. Conversely, an improvement in chest shape may not be accompanied by a change in physical capability. Objective, functional, and patient-reported outcomes should therefore be recorded and considered separately.

Objective monitoring may include standardised funnel depth measurements and three-dimensional surface scanning. The same patient position, anatomical reference points, and measurement method should be used for each assessment. Repeat CT imaging should not be performed solely to monitor the response to vacuum bell therapy. The Haller index should only be recorded when clinically indicated imaging has already been performed.

Patient-reported assessments should consider the following:

- Physical functioning and activity limitation
- Symptoms, including pain, breathlessness, dizziness, and exercise intolerance
- Satisfaction with chest appearance and body image
- Psychological well-being
- Treatment burden, adherence, and satisfaction with treatment

10.1 Physical functioning

Physical functioning should be assessed using an appropriate validated patient-reported outcome measure. Assessment should consider the extent to which the patient's health or chest wall condition affects everyday physical activities, exercise tolerance, and participation. The 10-item Physical Functioning domain of the 36-item Short Form Health Survey was originally developed by Ware and Sherbourne.[14] This assesses the extent to which an individual's health limits their ability to undertake a range of everyday physical activities. The SF-36 Physical Functioning Scale has also been shown to correlate strongly with a multitask performance measure of general physical function in an adult clinical population.[15]

The RESTORE trial uses the SF-36v2 Physical Functioning score as its primary outcome measure, comparing scores recorded before treatment with those obtained one year later.[16] Although RESTORE compares surgery with conservative treatment rather than evaluating vacuum bell therapy specifically, the assessment of physical functioning may also help orthotic and chest wall services identify changes during conservative treatment.

Other validated measures of physical function may also be considered, including PROMIS Pediatric Physical Function, which provides a standardised patient-reported assessment of physical functioning in children and adolescents using item banks and short forms.[17]

Where the SF-36v2, PROMIS Pediatric Physical Function or another validated outcome measure is used, clinicians and services must ensure that they hold the appropriate licence or permission for the intended use. Where an organisation already holds a licence, the service should confirm that the proposed clinical, research, teaching, or publication use is covered by the terms of that licence.

The authorised version of the selected measure should be used in accordance with the relevant instructions for administration, scoring, and interpretation. Copyrighted or licensed questionnaires should not be reproduced, adapted, or distributed unless the appropriate permission has been obtained.

Where a validated questionnaire cannot be used because of licensing or local governance requirements, services may record physical functioning using a locally developed assessment. Any such measure should be clearly identified as a local assessment and should not be presented as a validated SF-36v2, PROMIS, or other established outcome score, or compared directly with published scores derived from those instruments.

For vacuum bell therapy, physical functioning should be assessed before treatment begins and repeated at agreed review points using the same validated measure, wording, response options, and method of administration. It should be used alongside, rather than instead of, funnel depth or three-dimensional surface measurements, symptom reporting, and wider clinical assessment.

> **"The vacuum bell should be considered as a non-invasive, conservative treatment option for selected patients who are negatively impacted by their chest shape, whether physically or in terms of psychological well-being. It can be an effective option for motivated patients with mild to moderate pectus excavatum, offering the potential for improvement while avoiding the risks associated with surgery. Posture and breathing should also be addressed as part of treatment alongside the vacuum bell device."**
>
> **Isla Lundie, Respiratory Physiotherapist, Royal Hospital for Children, Glasgow**

10.2 Appearance, well-being and treatment experience

The physical functioning questionnaire does not measure cosmetic outcome, satisfaction with chest appearance, or body image. These outcomes should be explored separately. Where available, services should consider using an appropriate validated pectus-specific or body image measure. If a locally developed rating scale is used, it should be clearly identified and applied consistently throughout treatment.

When evaluating progress, clinicians should document whether the patient reports the following:

- Improved physical function or exercise tolerance
- Reduced symptoms
- Improved satisfaction with chest appearance
- Improved confidence or psychological well-being
- Any burden, discomfort or difficulties associated with treatment

A patient may report improvement in one outcome without improvement in another. These findings should be recorded separately and used to support shared decisions about continuing, modifying, or concluding treatment.

"The significant psychological and physical impairment suffered by so many pectus patients across the United Kingdom is compounded by the all too frequent rejection that they suffer when seeking medical help and advice. All too often patients that I now have to operate on due to their severity tell me how they sought help as a child or teenager only to be told that they would grow out of it or that it was 'just cosmetic' or that there was nothing that could be done.

I hope that this document will reset this injustice and encourage all young people and their families to seek the treatment they need and to be referred early so that they can benefit from conservative treatment and ultimately avoid expensive and significant surgery. NHS Highly specialised commissioning supports conservative treatment as the first step in the pathway for all pectus patients of any severity and it is my dream that one day every patient noticed to have a pectus deformity either by a GP or even a teacher or parent will be referred early, counselled and informed about their choices, and in the vast majority of cases offered conservative treatments to fully resolve their condition, leaving only a minority of patients requiring surgery.

Congratulations on this outstanding document and I encourage all clinicians to ensure that their local services adhere to this guideline."

Joel Dunning
Director of the Northern National NHS Pectus Centre, Chief investigator of the RESTORE Trial, Guideline Chairman of the Chest Wall International Group (www.cwig.info)

10.3 Vacuum bell treatment, review, and digital monitoring – a thoracic surgeon's perspective

The initial application of the vacuum bell should be supervised to confirm the correct device size and placement and to ensure that the patient or carer learns safe use.[18] One established protocol recommends 30 minutes twice daily for the first four to six weeks, followed by an individualised increase to several hours per day as tolerated.[18] Published protocols and overall treatment durations vary, and a standardised regimen has not been established. Longer daily use, overnight use, and a longer total treatment duration have been associated with a higher chance of treatment success.[19-21]

A review should be conducted every three to six months.[18,19] Patients should be advised to contact the service sooner if pain, persistent bruising, skin irritation, or other tolerance problems occur. Follow-up should include clinical examination, consistent external measurement of deformity depth, and standardised photographs. The prescribed and reported daily application time, skin effects, and other adverse effects should also be recorded.[18,19] Three-dimensional surface scanning may provide an additional radiation-free method of documenting chest wall change where it is locally available, but it is not required for routine follow-up.[22]

Applied negative pressure can be measured during clinic review, and electronic prototypes have been used to measure sternal elevation in relation to pressure. The pressure required to elevate the sternum is lower in younger patients and varies between individuals.[18,23] The available evidence does not support a single universal pressure target or demonstrate that higher pressure improves treatment outcomes.[20] Routine home monitoring of treatment frequency, duration, and pressure is not yet standard; therefore, self-reported use should be interpreted cautiously. Clinical decision-making should remain under specialist oversight.[24] Any device-generated data should supplement, rather than replace, clinical assessment.

A 2026 retrospective comparative cohort study found that both dynamic and standard vacuum therapy improved deformity depth at six months.[25] The mean correction and patient satisfaction were similar. Complete or near-complete correction was more common in the standard group. The dynamic group included more patients with an improvement of at least 1 cm and had fewer treatment discontinuations, but more minor skin complaints. The groups differed in age and baseline severity, and the analysis did not fully adjust for confounding. The findings, therefore, do not establish that dynamic systems are superior.[25] Device choice should be individualised and governed by the specialist multidisciplinary team.[24]

Dr Ahmed Habib
M.D., MSc., M.R.C.S., F.R.C.S.(CTh)
Robotic Lead for Thoracic Surgery
Consultant Thoracic Surgeon
The Royal Wolverhampton NHS Trust

"From a rehabilitation medicine perspective, early recognition of pectus deformities and timely access to conservative treatment are essential. Young patients need regular follow-up throughout growth to assess their progress and adapt treatment as their needs change. This guide provides a valuable framework for coordinated, multidisciplinary care and helps clinicians make informed decisions at each stage of treatment."

Anna Badowska MD
Specialist in Physical and Rehabilitation Medicine
Skoliozowe Love, Medical Centre, Wroclaw, Poland

11 Risks and Complications

Common risks associated with orthotic treatment include skin irritation, pressure-related discomfort, and adherence issues. These risks can be mitigated through patient education, gradual progression of wear time, and regular follow-up.

Treatment burden, body image concerns and changes in self-esteem may cause anxiety for children and their parents. Clinicians should recognise this risk, provide appropriate written resources and offer referral or signposting to psychological support services. Where direct referral is unavailable, ask the patient's GP to coordinate access to appropriate support.

Potential adverse effects include temporary skin discolouration, bruising, petechiae, discomfort, blistering, dizziness or fainting and loss of suction. Patients must stop treatment and seek clinical advice if they experience pain, skin injury, persistent bruising, breathing difficulty, chest pain, or fainting.

12 Guide review

This guide will be reviewed every three years, or sooner if important new evidence, safety information, or national policy changes emerge.

Case Study 1

Ethan was a 14-year-old boy who enjoyed school, spending time with his family and going bouldering at his local climbing centre at weekends. However, one day when getting dressed, he noticed that his chest wall appeared to be protruding, which initially concerned him, but he left it for a few days thinking it might go away. However, a couple of weeks later, he began to worry again and searched online for information about what might be causing the change.

When Ethan's mother Claire noticed his chest, she booked a GP appointment to see what help was available. Claire had also begun searching online for information about the condition, and was concerned by the limited public information available about the condition.

During this time, Ethan became more conscious of his chest, particularly when getting changed for PE at school, as his friends had noticed it. When asked what it was, he felt ashamed, because he did not know exactly what it was, and he began to avoid activities such as swimming or going to the beach with his family.

The solution

The GP suspected pectus carinatum (also known as 'pigeon chest') and referred him to a thoracic surgeon for confirmation of the diagnosis and discussion of treatment options. The surgeon then referred Ethan to the local orthotics department.

Ethan and his mother were immediately put at ease by their specialist orthotist Kate, whose positivity and confidence in the treatment were a complete contrast to the limited information they had been able to find online. Keen to get started, Ethan was fitted with his compression brace – an oval device with chest and back pads, designed to apply controlled pressure to the prominence and gradually remodel the chest wall. Unfortunately, the first couple of weeks were extremely uncomfortable for Ethan, as the asymmetric 'point' of his chest was particularly prominent and rubbed against the brace. However, after a few alterations were made and a softer layer of foam was added to the brace pads, Ethan was adamant about starting the treatment again, and this time, it was better tolerated.

After two months, the prominence had begun to reduce. This visible change increased Ethan's motivation to continue treatment. One of his proudest moments during the process was when he slept in the brace the whole night, as he was initially convinced he would not be able to.

After nearly a year, Ethan's chest was almost completely flat and he was able to reduce his brace-wear time gradually. He now feels confident when going out with his friends and does not shy away from activities like swimming; he even found that the brace did not disrupt his GCSE studies because he was no longer preoccupied by the appearance of his chest.

The bracing treatment had a significant positive effect on Ethan's mental health, as he now realises the detrimental impact the condition had been having on his life. "The thing I am looking forward to most is just feeling normal. I can now go out in public with confidence, wearing normal shirts and jumpers."

Returning to everyday activities and the hobbies he loves was the main aim for Ethan and his family, and he achieved it through sheer courage and determination when it came to the treatment process. His mother, Claire, is particularly proud: "Looking at a picture from a year ago, he's smiling, but it is not a happy, genuine smile. So compared to now, I can really see the difference the treatment has made to him."

During his treatment, Ethan was offered the opportunity to speak at the National BAPO Conference, where he bravely spoke about his treatment experience in front of clinicians who reported that his account had improved their understanding of the condition and its effect on young people.

Ethan's advice to anyone about to begin treatment is simple: "At first, it will be hard and difficult but just persevere and it will get easier. Get on with your everyday life, and it will be worth it. Just think – this treatment is only a small fraction of the rest of your life."

Case Study 2

A paediatric patient with pectus excavatum present since birth was referred to the Orthotics Service for assessment and conservative management using a vacuum bell device. The medical history included a repaired congenital diaphragmatic hernia. The patient was otherwise active, regularly participated in rugby, and only occasionally required an inhaler during sporting activities.

Prior to commencing treatment, the patient had experienced several episodes of fainting. While a direct causal relationship between these episodes and the chest wall deformity could not be definitively established, the episodes caused concern for the patient and family.

Initial Assessment

The patient attended clinic with their parents for assessment of suitability for vacuum bell therapy. Clinical examination identified a mild central pectus excavatum deformity with a funnel depth of approximately 9 mm.

A trial fitting of a small vacuum bell was undertaken. The device achieved a good fit, and an immediate rise of the chest wall was observed during application, demonstrating good correction potential. Although the patient was initially anxious and concerned that the treatment might be painful, the patient was able to independently apply the device and successfully achieve suction using the individually prescribed level of suction.

Education was provided regarding:

- Safe application and removal of the vacuum bell
- Wearing schedule
- Skin monitoring
- Device care and maintenance

Early Follow-Up

A telephone review was conducted with the patient's parents approximately six weeks after fitting.

The patient had been wearing the vacuum bell for around 2 hours daily and reported noticeable improvement in chest appearance. Although the depression returned after removal of the device, both the patient and family observed a visible difference and remained highly motivated to continue treatment.

The management plan was to:

- Gradually increase wear time
- Continue regular vacuum bell use
- Review progress in a further six weeks

Ongoing Progress

At a subsequent review, the patient's parent reported continued adherence to treatment. The patient was wearing the vacuum bell for approximately five hours per day and remained motivated by the improvements achieved.

As confidence with the device increased, the patient successfully progressed to overnight wear, allowing longer treatment sessions and supporting further correction of the deformity.

No further fainting episodes were reported during follow-up; no causal relationship with vacuum bell therapy can be inferred.

Challenges to Treatment

As is common during long-term conservative management, there were periods of reduced adherence, particularly during early adolescence when adherence to daily treatment became more challenging.

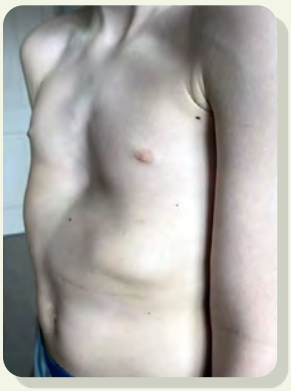
However, as the patient grew older and became increasingly aware of physical appearance and body image, motivation to continue treatment increased significantly. The patient recognised the improvements already achieved and recommitted to regular vacuum bell use.

This renewed engagement played a significant role in maintaining and further improving the correction achieved.

Imaging and Clinical Outcomes

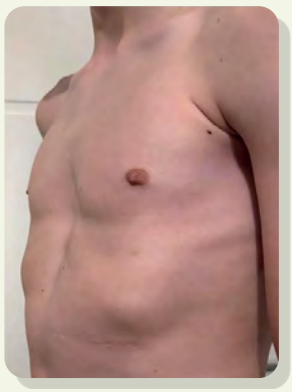
Formal radiological imaging was not documented within the orthotic records. Clinical assessment demonstrated a mild, flexible deformity with a measured funnel depth of approximately 9 mm.

Serial clinical photographs documented visible change over time. Comparison of photographs taken at 10 years of age (pre-treatment) and 12 years of age (following vacuum bell therapy) showed a visible reduction in the chest wall depression and marked improvement in anterior chest wall contour.



Pre-Treatment Appearance (Age 10)

- Visible central sternal depression consistent with pectus excavatum.
- Asymmetrical appearance of the anterior chest wall.
- Clearly defined funnel-shaped deformity.



Follow-Up Appearance (Age 12)

- Significant elevation of the previously depressed sternum.
- Improved chest wall symmetry and contour.
- Substantial reduction in the visible depth of the deformity.
- Improved overall chest wall appearance without surgical intervention.

Current Status

The patient continues to use the vacuum bell intermittently during periods of significant growth. This maintenance approach aims to minimise the risk of recurrence and preserve the correction achieved through treatment.

The patient remains highly motivated and engaged in self-management, understanding the importance of ongoing monitoring during adolescence while chest wall growth continues.

Discussion

This case demonstrates the successful use of vacuum bell therapy as a non-surgical treatment for mild pectus excavatum in a growing child. Key factors contributing to a positive outcome included:

- Early identification and treatment.
- A mild, flexible chest wall deformity.
- Strong family support.
- Progression to overnight wear.
- Absence of recurrent fainting episodes following treatment initiation.
- Renewed motivation during adolescence following recognition of cosmetic improvement.
- Continued maintenance treatment throughout growth periods.

The case also highlights that temporary periods of reduced adherence do not necessarily preclude successful outcomes if motivation and adherence are re-established.

Conclusion

Over a two-year period, conservative treatment with a vacuum bell resulted in a marked improvement in chest wall appearance, producing a visible improvement in a mild congenital pectus excavatum deformity without the need for surgery. Clinical assessment and photographs documented visible improvement, with the patient progressing to overnight wear and continuing maintenance treatment during growth to minimise the likelihood of recurrence.

In addition, several episodes of fainting were reported before treatment. No further episodes were reported during follow-up, but no causal relationship with the pectus deformity or vacuum bell therapy can be inferred. Although causation cannot be definitively established, this represented a notable improvement in the patient's clinical history.

This case demonstrates the potential effectiveness of vacuum bell therapy in selected and motivated paediatric patients and highlights the importance of long-term engagement during growth and development.

Syncope is a temporary loss of consciousness, commonly described as fainting or blacking out, caused by a brief reduction in blood flow to the brain. Pre-syncope describes the sensation of being about to faint, which may include dizziness, light-headedness, weakness, blurred vision or nausea, without complete loss of consciousness. Syncope or pre-syncope is an important clinical red flag and should not automatically be attributed to the pectus deformity. Syncope or pre-syncope requires prompt medical assessment to identify any underlying cause. Vacuum bell therapy should not begin until relevant medical assessment has been completed and the specialist team considers treatment safe.

Case Study 3

A 9-year-old boy was referred with central lower pectus carinatum. He was otherwise fit and healthy but had become increasingly concerned about the appearance of his chest as he grew older. Conservative treatment with a custom dynamic compression brace was chosen. The option of delaying treatment was discussed. However, the patient was mature for his age, understood the process and wished to address the chest wall prominence.

Initial Assessment
Clinical examination demonstrated a flexible central lower carinatum suitable for orthotic correction (Figure 1). The patient initially met the criteria for an off-the-shelf carinatum brace; however, the smallest size was too wide. A custom brace was prescribed following a three-dimensional surface scan.

The intensive protocol was discussed and agreed upon.

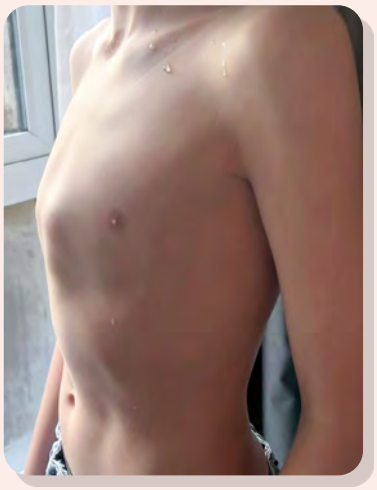


Figure 1. Before conservative treatment

Fitting of the brace
The pectus carinatum orthosis fitted well, and the patient was pleased with the ability to control the compression himself. Donning and doffing were practised, and the patient was optimistic about the treatment. Again, the protocol was discussed and wear and care instructions, including skin monitoring, were discussed.

Four-week follow-up
Marked improvement in chest shape was achieved. The patient had tolerated the brace well and had managed to adhere to the wearing schedule. The patient was happy with his chest shape, and the correction was maintained when the brace was removed.

Wear time was reduced to an evening maintenance schedule.

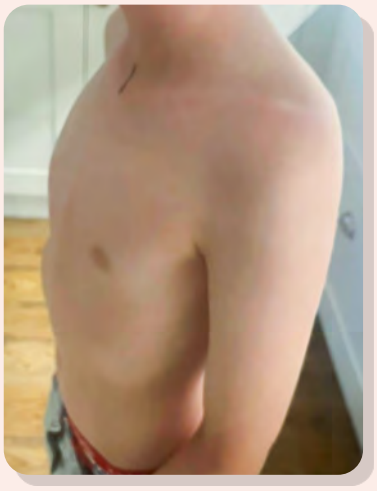


Figure 2. After completion of conservative treatment

Eight-week follow-up
The reduction in prominence had been maintained. The patient wore the brace for a few hours every second night. Wear time was planned to reduce further over the following weeks, and the brace was retained for future use if recurrence occurred during a significant growth spurt.

Outcome
Excellent cosmetic correction was achieved through high adherence with the intensive protocol. No complications were documented. The patient reported improved confidence and satisfaction with chest appearance.

Learning Points
1 Early intervention
2 Excellent adherence
3 Correct brace fitting
4 Gradual transition to maintenance wear

These factors, together with excellent family support, contributed to successful conservative correction of pectus carinatum.

Case Study 4

A patient's perspective

Thomas was about 13 years old when he first became aware of a protrusion in the centre of his chest. At first, it was not particularly noticeable but as he grew over the following year it became much more prominent to the point that it could be seen through his T-shirts.

Figure 1: Before: 06/08/25

Thomas was very keen to do something about it, so we initially visited our GP. The GP confirmed it was pectus carinatum and referred Thomas to a paediatrician.

The appointment took quite a few months to come through but the paediatrician took Thomas's concerns seriously and recognised that he was very motivated to do something to address this. At that stage, we were advised that treatment with a brace would require a significant commitment, including wearing it for the majority of each day.

Figure 2: After: 29/07/26

Around this time, Thomas started going to the gym and was becoming increasingly body conscious. His friends were aware of his condition and were supportive of him but the decision to seek treatment very much came from Thomas.

The paediatrician referred Thomas to the Chest Wall Clinic. It took a further few months for an appointment to come through. We were concerned that we were missing the window of opportunity to address the pectus carinatum as it continued to become more prominent. We researched treatment options and Thomas started suggesting that he felt surgery might be the best option to fix it.

Our experience at the Chest Wall Clinic has been incredible from the very start. Donna [Donna Dargie, orthotist] has been extremely supportive and encouraging while also being clear about the commitment that Thomas needed to achieve the best possible results from the brace.

Thomas was pleasantly surprised by the design of the brace – the thin, lightweight material meant that he has felt comfortable wearing it for long periods each day. Initially Thomas wore it while sleeping and at school. However, his school timetable included PE most days which led to him only wearing it outside of school times. The inbuilt monitoring tool, which recorded the number of hours the brace was worn, supported motivation and self-reflection.

One of the most encouraging aspects of the treatment was how quickly Thomas started to see results. He experienced some redness at the contact point initially, but it was manageable and never posed a significant issue.

During treatment, Thomas was attending the gym very regularly and experienced a significant growth spurt. As his chest muscles have developed, the clinic team made adjustments to the brace to ensure it continued to have the right level of contact with the centre of his chest. Donna has always been very helpful and available to provide advice and support with any concerns about fit or comfort, helping to make adjustments to the brace along the way. The mix of in-person and virtual appointments was helpful.

Thomas has worn the brace for about 18 months and the transformation has been remarkable. We are now gradually weaning him off the brace and he has only been wearing it at night and is about to reduce to every second night.

Thomas is extremely happy with the outcome, and as his parents, we're delighted and relieved that surgery isn't something we ended up having to consider. While Thomas's commitment to the treatment has undoubtedly played a major role in its success, the design of the brace and the ongoing support from the clinic have made the process far more manageable than we anticipated.

A huge thank you to Donna and the Chest Wall Clinic for making this such a positive experience for us. The treatment has made a huge difference, not only to Thomas's chest but to his future confidence and well-being. Without this support we have no doubt that the condition could have had a significant impact on Thomas as he grew older.

Case Study 5

Dynamic Bracing of a Moderate Right-Sided Pectus Carinatum

Initial assessment

David was referred after his mother noticed a chest wall prominence. His mother also had pectus carinatum.

Clinical examination demonstrated moderate, predominantly right-sided pectus carinatum extending from ribs six to eight, with minor involvement of the left side at the same level. The deformity was very flexible on correction, making David a suitable candidate for dynamic bracing.

David chose to proceed with treatment and was fitted with a semi-bespoke pectus carinatum orthosis. He was able to apply the brace independently and appeared motivated to engage with treatment.

Figure 1: Before and after conservative treatment

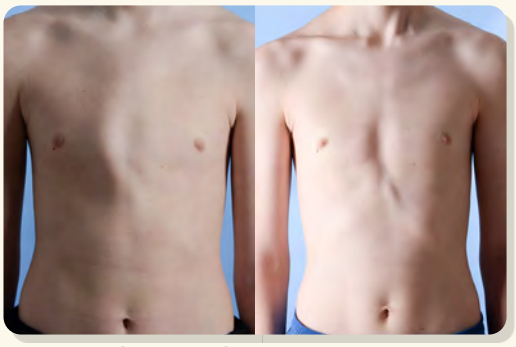


Figure 2: Before and after conservative treatment

Treatment progress

David adapted quickly to the brace, initially wearing it for approximately 16 hours per day, including overnight. He subsequently increased his wear to approximately 20 hours per day without difficulty.

At his first review, David maintained full-time brace wear and demonstrated substantial improvement. His previously moderate carinatum had reduced to very mild prominence.

At the subsequent face-to-face review, the carinatum had fully resolved. Data logger analysis demonstrated exceptional adherence, with an average wear time of 22 hours per day. His chest remained very flexible; therefore, he was advised that recurrence was possible during future growth. Comparative clinical photographs were obtained, and a staged weaning programme was initiated.

- One month at approximately 50% of the previous wear time.
- One month at approximately 25% of the previous wear time.
- One month without a brace.

Figure 3: Before and after conservative treatment

Follow-up and outcome

David completed the weaning programme and discontinued the brace without recurrence. At a subsequent review, the carinatum remained fully resolved, although his chest initially remained flexible. Continued observation was arranged because of the potential for recurrence.

At the final review, David had been out of the brace for approximately 22 months. His carinatum remained fully resolved, and his chest wall was inflexible. He reported no pain, functional limitations, or concerns about his chest shape.

David was discharged from the Chest Wall Service with a successful and sustained outcome following dynamic bracing.

Appendix 1: Suggested GP letter

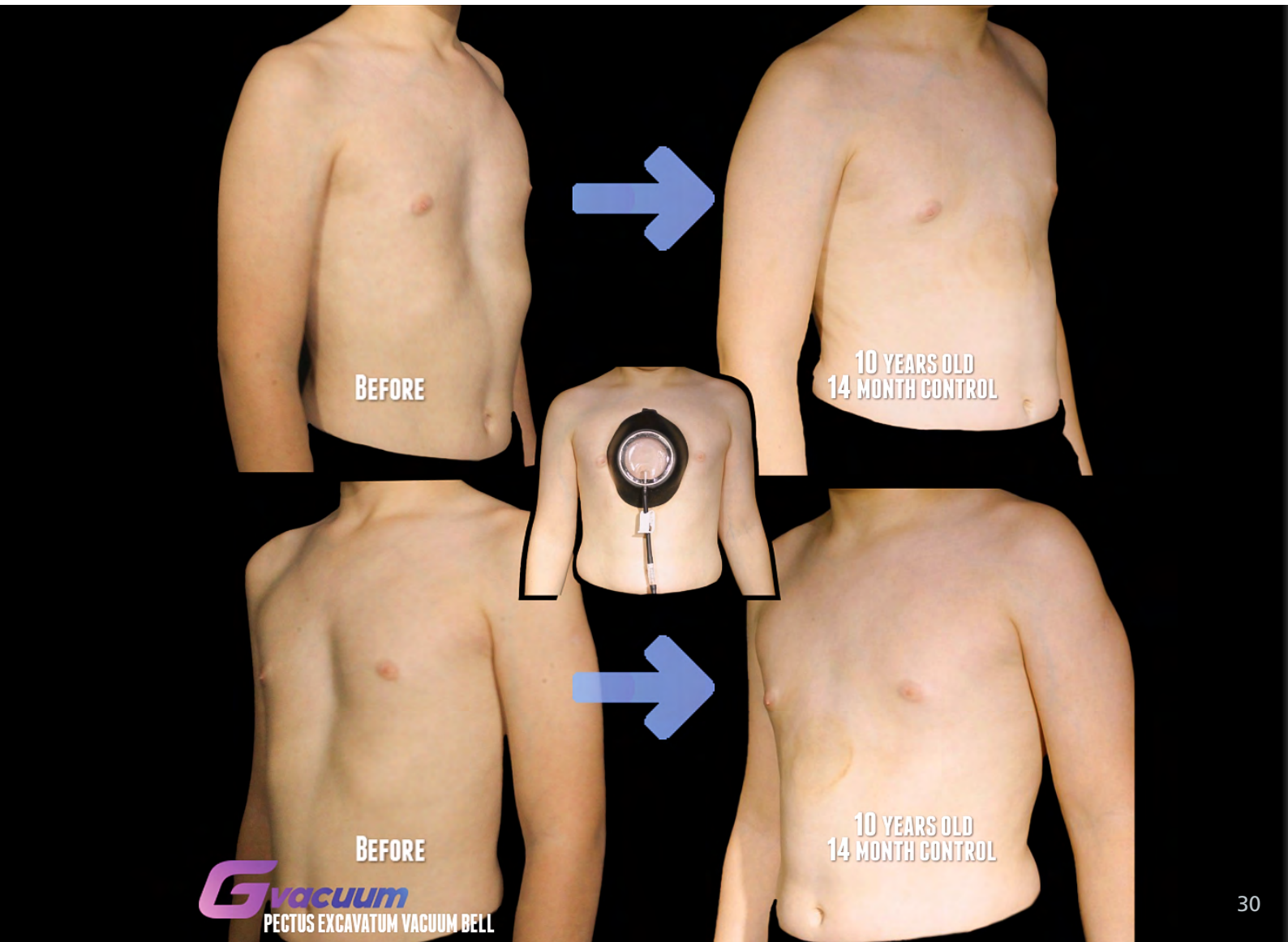
Patient Name
Patient DOB
NHS number
Address

Date
GP name and address
Subject line
Sender name and role
Contact details and sign-off

Dear GP,

Thank you for referring this patient to the paediatric surgery team for assessment of their chest wall deformity. We will manage this patient alongside the orthotics team based at [hospital name] and will refer the patient to the appropriate specialist chest wall MDT to consider surgery if this is clinically appropriate, available under the applicable commissioning policy and desired by the patient.

Connective tissue disorders, including Marfan syndrome and Ehlers-Danlos syndrome, may be associated with pectus deformities. If clinical features suggest an underlying connective tissue disorder, please refer the patient to the appropriate local clinical genetics and cardiology pathways for specialist assessment. Investigations and genetic testing should be determined by those specialist teams.



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Useful links

Mental health support
Changing Faces: visible difference support
www.changingfaces.org.uk/

Hub of Hope: mental health support directory provided by Chasing the Stigma
https://hubofhope.co.uk/

Policy documents
Chest wall bracing for children and young people with pectus carinatum
https://shtg.scot/our-advice/chest-wall-bracing-for-children-and-young-people-with-pectus-carinatum/

NHS England policy: surgery for pectus deformity (all ages)
www.england.nhs.uk/publication/surgery-for-pectus-deformity-all-ages/

NHS England interim policy statement: Interim clinical commissioning urgent policy statement: pectus surgery for pectus excavatum deformities resulting in very severe physiological symptoms (all ages)
www.england.nhs.uk/publication/interim-clinical-commissioning-urgent-policy-statement-pectus-surgery/

New advice for children living with chest abnormality welcomed by national treatment service
www.healthcareimprovementscotland.scot/publications/new-advice-for-children-living-with-chest-abnormality-welcomed-by-national-treatment-service/

Glossary

Abramson procedure (reverse Nuss procedure): A minimally invasive operation for pectus carinatum in which a metal bar is positioned across the front of the chest to remodel a prominent sternum.

Adams forward bend test: A clinical screening test for possible scoliosis. The patient bends forwards while the clinician observes the spine and rib cage for asymmetry.

Adherence: The extent to which a patient follows the agreed treatment plan, including the recommended daily wear time and review schedule.

Allied health professional (AHP): A member of one of the allied health professions recognised within the UK health system. Orthotists and physiotherapists are allied health professionals.

Anterior and posterior: Anatomical terms meaning the front and back of the body respectively.

Asymmetrical pectus deformity: A chest wall difference that is more pronounced on one side or involves rotation of the sternum.

Beighton score: A nine-point clinical scoring system used to assess generalised joint hypermobility. It may help identify patients who require further assessment for an underlying connective tissue disorder.

Calgary protocol: A staged pectus carinatum bracing protocol in which wear time is gradually increased during the correction phase and reduced to maintenance wear once correction is stable.

Cardiopulmonary symptoms: Symptoms involving the heart or lungs, such as breathlessness, chest pain, fainting, palpitations or reduced exercise tolerance.

Chest compression orthosis: A brace that applies controlled pressure to a prominent area of the chest wall to treat flexible pectus carinatum. It may also be called a pectus carinatum orthosis.

Chondrogladiolar pectus carinatum: The most common form of pectus carinatum, involving prominence of the middle or lower part of the sternum. It is often flexible and may respond well to bracing.

Chondromanubrial pectus carinatum: A less common and typically stiffer form of pectus carinatum involving prominence of the upper sternum. It may occur as part of the complex presentation described as pectus arcuatum and is generally less responsive to bracing.

Conservative management: Treatment that does not involve surgery. In this guide, it includes chest compression bracing, vacuum bell therapy, physiotherapy, exercise and psychological support.

Connective tissue disorder: A condition affecting tissues that support structures throughout the body. Examples include Marfan syndrome and Ehlers-Danlos syndrome. Some connective tissue disorders are associated with pectus deformities.

Contraindication: A condition or circumstance in which a particular treatment should not be used because it may be unsafe or carry an unacceptable risk.

Correction phase: The initial stage of bracing during which the orthosis is worn for the prescribed period each day to achieve correction of the chest wall prominence.

Costal cartilage: The flexible cartilage connecting the ribs to the sternum. Its flexibility is an important factor in determining whether a pectus deformity is likely to respond to conservative treatment.

CT scan: Computed tomography imaging that produces detailed cross-sectional images of internal structures. It may be used to assess the internal severity of pectus excavatum.

Donning and doffing: Putting on and removing a brace or vacuum bell device.

Dyspnoea: The clinical term for breathlessness or difficulty breathing.

Funnel depth: An external measurement of the depth of the chest wall depression in pectus excavatum. It can be used to monitor change during vacuum bell treatment.

Haller index: A measurement used to describe the internal severity of pectus excavatum. It is calculated from chest imaging by dividing the internal width of the chest by the shortest distance between the sternum and spine.

Hypermobility: A greater than usual range of movement in one or more joints. Generalised hypermobility may be associated with an underlying connective tissue disorder.

Intensive protocol: A pectus carinatum bracing protocol involving prolonged daily wear with minimal removal during the correction phase. It requires careful patient selection and close clinical monitoring.

Maintenance phase: The stage following initial correction when brace wear is reduced to help maintain the corrected chest shape during continuing growth.

Medical illustration: A specialist clinical imaging service that produces standardised photographs or three-dimensional images to document presentation and monitor change over time.

Modified or surface Haller index: An estimate of chest wall shape derived from external measurements or a three-dimensional surface scan rather than internal CT imaging.

Multidisciplinary team (MDT): A group of health professionals from different clinical disciplines who work together to assess, plan and deliver care. A pectus MDT may include surgery, orthotics, physiotherapy, psychology, respiratory medicine, specialist nursing and other services.

Newton (N): A unit used to measure force. In this guide, it is used when describing the corrective force required to compress a pectus carinatum prominence.

Orthosis: An externally applied medical device used to support, align, protect or change the structure or function of part of the body. A chest compression brace is a type of orthosis.

Orthotist: A registered allied health professional specialising in the assessment, prescription, fitting and review of orthoses. In pectus care, the orthotist commonly manages chest compression bracing and may contribute to vacuum bell treatment.

Pectus arcuatum: A complex chest wall presentation involving prominence of the upper sternum with depression of the lower sternum. It is sometimes described as a combined carinatum and excavatum deformity.

Pectus carinatum: A chest wall deformity in which part of the sternum and adjacent ribs project outwards. It is sometimes called pigeon chest.

Pectus carinatum orthosis: A chest compression orthosis that applies controlled corrective pressure to a flexible pectus carinatum prominence.

Pectus excavatum: A chest wall deformity in which the sternum and adjacent chest wall are depressed inwards. It is sometimes called funnel chest.

Pounds per square inch (psi): A unit used to measure pressure. Pressure and force are different physical quantities, so psi and newtons should not be treated as directly interchangeable without taking the contact area into account.

Pressure or force of correction: The externally applied pressure or force required to correct the chest wall prominence during clinical assessment. It provides an indication of chest wall flexibility and likely suitability for bracing. The unit, device and threshold must be stated explicitly whenever this measure is reported.

Patient-reported outcome measure (PROM): A questionnaire or rating completed by the patient to describe symptoms, function, well-being, treatment experience or satisfaction with chest appearance.

Psychosocial impact: The effect of a condition on psychological well-being and social participation, including body-image, confidence, relationships, education and everyday activities.

Ravitch procedure: An open operation in which abnormal costal cartilage is removed or reshaped and the sternum is repositioned, sometimes with temporary internal support.

Red flag: A clinical feature that may indicate a significant associated condition or a need for further specialist investigation. Examples in pectus care include significant cardiopulmonary symptoms, rapid progression, scoliosis, suspected connective tissue disorder and significant psychological distress.

Scoliosis: A three-dimensional curvature and rotation of the spine. It occurs more frequently in people with pectus deformities and may require specialist spinal assessment.

Sternum: The breastbone located at the centre of the front of the chest.

Three-dimensional surface scan: A non-invasive method of capturing the external shape of the chest. It can support assessment, brace design and monitoring of changes over time.

Thoracic or chest wall service: A specialist service that assesses and manages conditions affecting the chest, ribs and sternum.

Vacuum bell therapy: A conservative treatment for selected patients with pectus excavatum. A suction device applies negative pressure to encourage gradual elevation of the depressed sternum and is used according to an individually prescribed wearing schedule.

“As a researcher, but above all as a physiotherapist working with patients every day, I see pectus as much more than a change in the shape of the chest. We need to look at the whole person, their posture, breathing, and movement, but also how they feel in their own body. This is where physiotherapy can really make a difference.”

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As someone who experienced pectus carinatum myself and underwent surgery at the age of 17, and now treats people with pectus as a surgeon, I am delighted to see guidelines supporting non-invasive treatment options. I strongly believe that non-invasive treatment should be offered as the first-line approach wherever possible and should be readily available across all regions. Young people with pectus deserve timely access to effective treatment, support, and specialist care, regardless of where they live.

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