

Hemivertebra

A patient guide

In brief: A hemivertebra is a congenital vertebral anomaly, meaning a difference in the shape of a spinal bone that is present from birth. It belongs to the group of malformations described as a failure of formation, in which only part of a vertebra develops as the spine is being laid down in early pregnancy. In its classic form, just one half of a vertebral body forms, producing a triangular wedge of bone, often with a single pedicle and half an arch behind it, rather than the rounded, symmetrical block of a normal vertebra. Because this wedge is taller on one side than the other, it can tilt the bones above and below it and seed a sideways curve, a congenital scoliosis, or a forward-bending curve, a congenital kyphosis, depending on where the missing portion lies. The single most important idea is that a hemivertebra is a structural building-block difference set down before birth, not a curve that develops later from posture or wear, and that its behaviour over time varies enormously: some remain incidental and stable throughout life, while others drive a curve that grows as the child grows.

What a hemivertebra is (a building-block difference present from birth)

The spine is built from a column of bones, the vertebrae, stacked one upon another and separated by discs. Each vertebra normally forms as a roughly symmetrical block, the vertebral body at the front, with a bony arch behind it carrying two pedicles and the rest of the protective ring around the spinal cord. This architecture is established very early in pregnancy, between roughly the fifth and eighth weeks, when blocks of tissue along the developing back, the somites, divide and reorganise to become the vertebrae and ribs.

A hemivertebra arises when this process goes partly awry on one side. Instead of a full, balanced vertebral body forming, only one half develops, while the other half fails to appear. The result is a wedge-shaped piece of bone, broad on the side that formed and tapering to a point on the side that did not. In its full form it carries a single pedicle and one half of the bony arch behind. Because the bone is taller on one edge than the other, it acts rather like a wedge slipped into a stack of bricks: it tilts everything resting upon it.

This is what makes a hemivertebra a distinct entity, and it is worth stating plainly because it is so often confused with the common curves seen in adolescence. A hemivertebra is a difference in the way a bone was built, fixed in place from birth. It is not a curve that has crept in over the years from posture, habit, growth spurts or wear, which is the situation in the far commoner adolescent idiopathic scoliosis. The shape was set down in the first weeks of life, long before the child could stand or walk, and the curve that may follow is a downstream consequence of that single misshapen brick.

That framing explains why the field talks so much about formation and segmentation. A normal vertebra represents both a complete formation of the bone and a clean separation, or segmentation, from its neighbours by a disc on each side. A hemivertebra is fundamentally a failure of formation, half the bone is simply missing, and its later behaviour depends heavily on how cleanly it is segmented from the bones above and below it.

How a hemivertebra can tilt the spine into a congenital curve

The reason a hemivertebra matters is mechanical, and it follows directly from its wedge shape. When a bone is taller on one side than the other and is wedged into a vertical stack, the stack is forced to lean. If the wedge points sideways, the spine tilts into a sideways curve, a scoliosis. If it points backwards, the spine tilts into a forward-bending curve, a kyphosis. Many hemivertebrae produce a combination of the two.

Whether that initial tilt stays small or grows depends on growth. A child's spine has growth plates, and the segments around a hemivertebra continue to lengthen as the child develops. If the hemivertebra itself has live

growth plates on both its top and bottom surfaces and is free to grow, it adds height to one side of the spine year on year, steadily deepening the curve as the child grows taller. If, instead, the hemivertebra is welded to its neighbours and has little growth potential of its own, the wedge is largely static and the curve it produces tends to stay modest.

This is why a congenital curve is so different in character from the more familiar adolescent curve. The driving force is not a poorly understood tendency of an otherwise normal spine to bend, but a concrete, identifiable structural cause, a wedge of bone, whose growth behaviour can to some extent be read from its shape and its relationship to its neighbours on a scan. The literature consistently emphasises that the rate at which these curves progress is highly variable, reported across a very wide range from barely any change to many degrees each year, with the type and site of the hemivertebra among the main factors.

The segmentation subtypes and why they behave so differently

Not all hemivertebrae behave alike, and the most useful way of telling them apart is by how they are separated, or segmented, from the vertebrae above and below. This classification, attributed to McMaster and others, sorts hemivertebrae into types that carry very different outlooks because they imply very different amounts of independent growth.

****Fully segmented.**** A fully segmented hemivertebra has a normal disc both above and below it, separating it cleanly from its neighbours. It therefore possesses its own working growth plates on both surfaces and is free to grow independently. This is the type with the greatest growth potential and, accordingly, the one most likely to add height to one side of the spine and to drive a progressive curve.

****Semi-segmented.**** A semi-segmented hemivertebra has a disc on only one side; on the other side it is fused, joined directly, to the adjacent vertebra. With only one functioning growth surface, it has less independent growth potential than the fully segmented type and tends to produce a less aggressive curve.

****Non-segmented.**** A non-segmented hemivertebra is fused to the vertebrae on both sides, with no normal disc separating it. Locked into a block with its neighbours, it has little or no independent growth, and so tends to cause comparatively little deformity. Such block-like anomalies are often the ones that remain stable.

****Incarcerated.**** An incarcerated hemivertebra is a particular variant in which the wedge is small, oval and tucked, or set, into matching notches in the vertebrae above and below, so that the column above remains reasonably well aligned over the column below. Because the neighbouring bones accommodate the wedge and its own growth is limited, an incarcerated hemivertebra tends to cause little deformity. The opposite arrangement, a non-incarcerated hemivertebra that juts out from the side of the column, displaces the alignment more and is associated with greater curvature.

The thread running through this classification is growth. The more independent growth potential a hemivertebra retains, signalled by open discs on both sides, the more it tends to progress; the more it is fused into a static block, the more it tends to stay put. This is why the same word, hemivertebra, can describe both an incidental, lifelong-stable finding and the engine of a severe, rapidly worsening childhood curve.

The worst combination: a hemivertebra opposite a bar

There is one pattern that the natural-history literature singles out as the most ominous of all the congenital anomalies, and understanding it requires one further idea, the unsegmented bar. A bar is the mirror-image problem to a hemivertebra: instead of a failure of formation, it is a failure of segmentation, a length of bone on one side of the spine where several vertebrae that should have been separated by discs are instead fused into a solid, growth-arrested strut. A bar on one side acts as a tether, anchoring that side of the spine so it cannot lengthen.

The dangerous situation arises when an unsegmented bar lies on one side of the spine and a fully segmented hemivertebra sits on the opposite side. The result is the most unbalanced growth the spine can experience. The bar prevents the concave side from growing at all, while the hemivertebra actively pushes the convex side to grow faster. One side is held fast while the other is driven forward, and the curve worsens relentlessly. The published natural-history studies describe this hemivertebra-opposite-a-bar combination as carrying the worst prognosis and the most rapid progression of any congenital pattern, frequently producing severe curves at a young age. It sits at the opposite end of the spectrum from a quiet non-segmented or incarcerated hemivertebra, and it illustrates why describing exactly what anomaly is present, and what lies opposite it, matters so much more than the label hemivertebra alone.

Why the site of the hemivertebra matters

Alongside the segmentation type, the position of a hemivertebra along the spine shapes how it behaves. A hemivertebra high in the chest may tilt the head and shoulders and disturb the balance of the trunk, while one low in the back can throw the pelvis out of level and influence how a child stands. The junction between the chest and the lower back, the thoracolumbar region, is described in the literature as a site where curves tend to behave particularly unfavourably, and the majority of isolated hemivertebrae are reported to cluster around this region. A hemivertebra in the lower back or at the very base of the spine, the lumbosacral junction, sits on the foundation of the column, so even a modest tilt there can require a longer compensatory curve above it to keep the head centred over the pelvis. The interplay of site, segmentation type and the number of anomalies present is what gives each congenital curve its own individual character.

What can accompany a hemivertebra: associated anomalies and screening

A hemivertebra is laid down at the same early stage of pregnancy, and through related developmental processes, as several other organ systems. For this reason it is frequently not an isolated finding, and its discovery is widely regarded in the literature as a prompt to look more widely for associated differences elsewhere in the body.

The most recognised grouping is the VACTERL association, a non-random tendency for certain malformations to occur together: Vertebral anomalies such as hemivertebrae, Anal differences, Cardiac anomalies, Tracheo-oesophageal differences, Renal (kidney) anomalies and Limb differences. Vertebral anomalies including hemivertebrae are among the commonest findings in this group, and a notable proportion of children with a hemivertebra are reported to carry one or more of the other features.

Two systems in particular draw attention. The first is the kidneys and urinary tract, because kidney anomalies, such as a missing or underdeveloped kidney, are reported in a meaningful minority of children with congenital vertebral differences, and an ultrasound scan of the abdomen is a simple way of looking for them. The second is the spinal cord itself. Children with congenital vertebral anomalies have an increased likelihood of differences within the spinal canal, including a low-lying or tethered spinal cord, a split cord, or other features of spinal dysraphism, present in roughly a third of cases in some series. The heart is a further focus, given the frequency of associated cardiac anomalies, and a heart assessment is commonly part of the wider picture. Some hemivertebrae also arise within recognised genetic conditions affecting the segmentation of the spine, such as the spondylocostal dysostoses, where mutations in genes governing the early "segmentation clock" disturb the formation of many vertebrae and ribs at once.

The practical thread is that finding a hemivertebra is, in current practice, treated as a reason to consider screening the kidneys, the heart and the spinal cord, because identifying any associated difference early forms part of a complete picture. This is a description of why such screening is undertaken, not advice for any individual.

How a hemivertebra is identified and assessed on imaging

Because a hemivertebra is a difference in the shape of bone, imaging is central both to identifying it and to understanding how it is behaving over time.

****Plain X-rays**** are the foundation. A standing X-ray of the whole spine shows the characteristic wedge of a hemivertebra, reveals the curve it has produced, and allows that curve to be measured. Critically, X-rays repeated over time, compared carefully against the earliest baseline film, are the principal way of judging whether a curve is staying still or progressing, which is the single most important question in a growing child. Modern low-dose whole-spine imaging systems allow these repeated assessments with reduced radiation.

****Computed tomography, the CT scan****, with its three-dimensional reconstructions, gives the clearest picture of the exact bony anatomy, defining precisely which portion of the vertebra is missing, identifying any unsegmented bar opposite the hemivertebra, and clarifying complex or multiple anomalies that are hard to read on a plain film. Because it carries a higher radiation dose, it is used selectively, typically when detailed bony detail is needed, for instance when surgery is being considered.

****Magnetic resonance imaging, the MRI scan****, does not show bone as sharply but is the means of examining the spinal cord and its coverings. It is widely described as an important part of the assessment of congenital vertebral anomalies precisely because of the frequent association with hidden differences inside the spinal canal, such as a tethered cord or a split cord, which may not be apparent from the bones or from examination alone.

****Ultrasound and other scans**** of the abdomen and heart are used to look for the associated kidney and cardiac anomalies described above. Together these tests build a three-dimensional understanding of the bony difference, the curve it has produced, the structures inside the spinal canal, and the state of the other organ systems that share its developmental origin.

What the evidence shows about management (observation through to specialist surgery)

It is important to be clear at the outset that this section describes, in general terms, what the published literature reports about the range of approaches to hemivertebra and congenital curves. It is strictly educational. It is not advice, it does not recommend any course for any individual, and decisions in practice are highly individualised and rest entirely with a person's own specialist team. The evidence base in this field is built largely on observational series and long-term follow-up studies rather than large randomised trials, reflecting how uncommon and varied these anomalies are.

****Observation**** is the course the literature describes for hemivertebrae that are stable, balanced or judged at low risk of progression, the incidental, often non-segmented or incarcerated findings that cause little deformity. Here the approach described is careful monitoring with serial X-rays over time, particularly during periods of rapid growth, to confirm that the curve is not advancing. Many such curves remain modest and require nothing more than continued watching.

****Bracing and casting**** occupy a limited and particular role. Unlike the flexible curves of adolescence, a congenital curve is driven by a fixed bony wedge, so a brace cannot correct the underlying anomaly. The literature describes bracing or serial casting as used selectively, mainly to help control long, flexible compensatory curves that develop above or below a rigid congenital segment, rather than to treat the hemivertebra itself.

****Surgery**** is described in the literature for curves that are progressing, are severe, or carry a high risk of relentless worsening, the fully segmented hemivertebra and, above all, the hemivertebra-opposite-a-bar pattern. A

range of operations is reported. Convex growth arrest, or hemiepiphysiodesis, aims to stop growth on the longer side of the curve so that continued growth on the shorter side gradually evens things out, a technique described for selected younger children with smaller curves. Hemivertebra excision involves removing the offending wedge of bone entirely and correcting the curve with instrumentation across a short segment, and published series report substantial curve correction with this approach. For very young children with extensive or multiple anomalies, growth-friendly systems such as growing rods are described, designed to control the deformity while still allowing the chest and spine to keep growing. The overarching themes in the literature are that intervening earlier and over fewer segments is generally favoured when a curve is clearly progressive, and that every one of these decisions is weighed individually by the treating team against the risks of surgery.

In summary, the published evidence points towards observation for the stable, low-risk hemivertebra, a limited supporting role for bracing of compensatory curves, and specialist deformity surgery reserved for the progressive or high-risk curve, all within a framework of individualised, specialist-led decision-making rather than any fixed rule.

Specialist deformity assessment

Because the behaviour of a hemivertebra spans such a wide range, from an incidental lifelong-stable finding to the most rapidly progressive of all spinal curves, the literature consistently frames its evaluation as a task for specialist deformity assessment. That assessment draws together the precise bony anatomy on imaging, the segmentation type and what lies opposite the hemivertebra, the site along the spine, the trend of the curve across serial films, the stage of the child's growth, and the screening of the associated organ systems. It is the combination of all these threads, rather than any single measurement, that allows a curve to be characterised and followed appropriately. Nothing in this guide substitutes for that individual assessment.

Outlook

The outlook with a hemivertebra is, more than almost any other spinal condition, a matter of which hemivertebra is being described, because the category spans two very different stories. At one end lie the quiet anomalies, the non-segmented blocks and the incarcerated wedges that the body has largely accommodated, frequently discovered incidentally, producing little deformity and remaining stable throughout life with no more than periodic monitoring. At the other end lies the fully segmented hemivertebra, and especially the hemivertebra set opposite an unsegmented bar, which can drive a severe and rapidly progressive curve from a young age.

What the literature emphasises is that this trajectory can, to a useful degree, be anticipated from the shape and relationships of the anomaly on imaging and from the trend of the curve over time, which is why careful, repeated assessment during growth is so central. For the great many children whose hemivertebra is stable, the long-term picture is reassuring. For those whose curve is progressive, the same body of work describes a range of specialist treatments capable of controlling the deformity. Across the whole spectrum, the consistent themes are that a hemivertebra is a structural difference present from birth rather than a curve that crept in later, that its growth behaviour governs its outlook, and that any individual prognosis is a matter for assessment by a specialist team rather than something that can be read from the word hemivertebra alone.