CAN TRENDELENBURG’S SIGN BE POSITIVE IF THE HIP IS NORMAL?

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In 1895 Trendelenburg described his sign to determine the integrity of hip function. We found the sign to be positive in a patient whose hip was clinically and radiologically normal, and therefore investigated this in other patients. We confirmed that a medial shift of the mechanical axis of the leg below the hip may cause a positive Trendelenburg sign. This has not been previously described.

In 1895 Freidrich Trendelenburg described a clinical sign useful for determining the integrity of the function of hip abductor muscles, with specific reference to congenital dislocation of the hip and progressive muscular atrophy.1 His report appeared when physicians had few aids to diagnosis: clinical radiography was not yet available, since Roentgen had discovered X-rays only two years earlier.2 Most orthopaedic and physiotherapy textbooks describe the Trendelenburg sign as a diagnostic test of function and dysfunction of the hip. Apley’s System of orthopaedics3 gives the following description: “Normally each leg bears half the body weight. When one leg is lifted the other takes the entire weight. As a result the trunk has to incline towards the weight-bearing leg. This is achieved by the hip abductors; their insertion is fixed and the pull is exerted on their origin. Consequently the pelvis tilts, rising on the side not taking weight. When this mechanism fails Trendelenburg’s sign is positive. The pelvis drops instead of rising on the unsupported side” (Fig. 1).

The Trendelenburg sign becomes positive when there is abductor weakness, as in poliomyelitis or muscular dystrophies. It is also positive in coxa vara when there is insufficient room for abduction and the trochanter meets the pelvic wall before the pelvis can tilt sufficiently3 if the hip is dislocated and there is no stable fulcrum, and if the femoral neck is fractured so that the lever system is destroyed.

We had reason to re-examine the mechanism of the Trendelenburg sign when a 65-year-old man came to us with a middle-third tibial fracture malunited for ten years in 37° varus. His complaints were deformity and a limp, occasionally with knee pain. He was found to have a Trendelenburg gait but none of the causes listed above could be confirmed. We disregarded the sign and corrected his tibial deformity. After this realignment of the tibia we were surprised that the Trendelenburg gait had disappeared. We therefore studied similar cases to determine the real mechanism of a Trendelenburg gait in a patient with normal hips.

PATIENTS AND METHODS

We selected 17 patients and studied 23 legs. All the patients had an acquired Trendelenburg gait (Fig. 2). None had fixed scoliosis, fixed pelvic obliquity, obvious pathology of the hip, muscle weakness due to poliomyelitis or dystrophy, any painful conditions which prevented standing on the leg,

Fig. 1

Diagram showing the lever system which acts in abduction of the hip.

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or altered function of the hip abductor muscles. Clinical and radiological examination confirmed this normality and hip abductor power was MRC grade 5 in all cases. Deformity of the leg was assessed by full-length standing radiographs from hip to heel. Monopodal weight-bearing radiographs of the pelvis (Fig. 3) were taken if the leg deformity was only diaphyseal, and full leg-length films if the deformity was juxta-articular to evaluate its magnitude when bearing weight.

**Definition of mechanical axis.** The mechanical axis of the limb was taken to be a line connecting the centre of the femoral head to the centre of the ankle mortice. Normally, this passes through the tibial spine of the knee. We defined medial or lateral shift of the measured line as medial or lateral deviation of the mechanical axis of the limb.\(^{4-7}\)

In a normal limb, a line from the centre of the femoral head to the tip of the greater trochanter (hip orientation line) is usually at about 90° to the mechanical axis (Fig. 4), and in the tibia, the mechanical and anatomical axes are the same. In the femur, the mechanical axis is from the centre of the femoral head to the centre of the knee, and the anatomical axis is from the piriformis fossa to the centre of the knee. The two lines subtend about 6° to each other,\(^{4-7}\) the anatomical axis of the femur at the hip is in 6° of adduction during normal walking.

**RESULTS**

Of the 17 patients whom we studied (23 limbs), three had bowing deformity of both lower limbs (Fig. 5), four had malunited fractures of the femoral shaft, five had osteoarthritis of the knee with varus deformity (Fig. 2), four had diaphyseal tibia vara and one had Blount’s disease.

For the planning of surgical correction the magnitude,
level and plane of the deformity were assessed by the methods described by Paley.\textsuperscript{4-7} In bowing deformities the angle of the hip orientation line to the ankle mortice was recorded (measured as Cobb method of scoliosis) as a gross assessment. All of the patients had medial deviation of the mechanical axis at the knee with or without ligamentous laxity.

**DISCUSSION**

The main plane of knee and ankle movement is in flexion and extension around a coronal axis. If the axis of fracture malunion is in the coronal plane these joints and the hip can compensate so that the gait looks normal. The hip is the only joint in the lower limb which allows much adduction and abduction and therefore any varus or valgus deformity of the leg can be compensated for only at the hip, and to a minimal extent at the subtalar joints. Any varus or valgus deformity between the hip and ankle must therefore influence hip mechanics. Varus deformity of the femur, knee, or tibia requires the hip to adopt an abducted position (valgus angulation) to maintain a straight mechanical axis of the limb in walking. The mechanics of hip abduction act as a type-III lever, with its fulcrum at the centre of the femoral head: the abductor muscles are inserted below the tip of the greater trochanter (Fig. 1). When the centre of the head and the tip of the trochanter are in the same plane, parallel to the floor, then the insertion is distal to the fulcrum.

If the hip is abducted in compensation for a varus deformity below the hip, the trochanter rotates proximally in the coronal plane so that it is above the fulcrum (Fig. 6), thus effectively shortening and weakening the abductor muscles. The angle between the hip orientation line and the mechanical axis of a varus limb will exceed 90° and the 6° adducted position of the femur in normal walking is lost. This affects the strength that can be generated by the abductor muscles although they are normal (Fig. 7). Depending on the amount of compensation, these patients will have either a normal gait, a delayed Trendelenburg sign\textsuperscript{2} or a Trendelenburg gait. Medial deviation of the mechanical axis is thus another cause of a Trendelenburg gait or sign.

We suggest that the Trendelenburg sign should now be classified as having three possible mechanisms:
1) Suprapelvic. Costopelvic impingement as in scoliosis.

2) Pelvic. This is due to loss of the fulcrum as in developmental dysplasia of the hip; or of the lever mechanism as in nonunion of the femoral neck; or of power as in poliomyelitis or muscular dystrophy.

3) Infrapelvic. This is caused by medial deviation of the mechanical axis of the lower limb.

The positive Trendelenburg sign due to infrapelvic causes can be easily differentiated from that due to classical causes. During normal monopodal weight-bearing the medial border of the thigh, which is roughly parallel to the mechanical axis of the femur, is perpendicular. In patients with pelvic causes of a positive Trendelenburg sign the thigh is orientated obliquely and inwards (adducted at the hip) (Fig. 8).

In patients with a positive Trendelenburg sign due to infrapelvic causes the medial border of the thigh proximal to the site of a varus deformity, is orientated obliquely and outwards, that is, abducted at the hip (Fig. 9). The part of the limb distal to the deformity is orientated obliquely and inwards. In patients with proximal varus deformity of the femur or coxa vara this clinical sign is difficult to assess because of the bulkiness of the thigh and proximity to the hip. Such patients will appear to have a classical Trendelenburg sign because only that part of the limb distal to the varus deformity can be observed.

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