Mononeuropathies: trunk
**Phrenic nerve**

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<tr>
<th>Genetic testing</th>
<th>NCV/EMG</th>
<th>Laboratory</th>
<th>Imaging</th>
<th>Biopsy</th>
<th>Pulmonary function tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ NCV EMG of the diaphragm</td>
<td>+ –</td>
<td>+</td>
<td>+ X ray Ultrasound of diaphragm</td>
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**Fig. 22.** Phrenic nerve is in the vicinity of the pericardium. 1 Right Phrenic nerve. 2 Left Phrenic nerve. 3 Anterior portion of Diaphragm
The phrenic nerve fibers are from C3, 4, and 5. The connection with C3 may be via the inferior ansa cervicalis (cervical plexus). The nerve travels over the anterior scalenus muscle, dorsal to the internal jugular vein, and crosses the dome of the pleura to reach the anterior mediastinum. On the right side, it is positioned next to the superior vena cava and near the right atrium. Sensory branches innervate the pericardium. After transversing the diaphragm, the phrenicoabdominal branches supply the peritoneum of the diaphragm, liver, gall bladder and pancreas. Terminal branches end in the celiac plexus (Fig. 22).

Unilateral lesion: mild dyspnea, or asymptomatic.
Bilateral lesions: age dependent, with babies and small children developing respiratory problems. Newborns with bilateral lesions require ventilation.
Adults are easily dyspneic, particularly upon exertion, and unable to lie in a supine position.

Birth trauma (with or without associated brachial plexus lesions)
Idiopathic
Polyneuropathies (AIDP, critical illness, multifocal neuropathy with conduction block)
Neuralgic amyotrophy

Chest:
Intrathoracic malignant tumors
Chest operations (intraoperative mechanical or local cooling)
Neck wounds
Traction, with upper trunk of brachial plexus damage
Chest radiograph

**Fig. 23.** Diaphragmatic injury.  
A Diaphragmatic paralysis.  
B Inspiration.  
C Expiration
Clinically: respiration, ability to recline supine (Fig. 23)
Electrophysiology: NCV, EMG of diaphragm
Pulmonary function tests
Transdiaphragmatic pressure

Adult onset maltase deficiency
Herpes zoster with motor involvement
Motor neuron disease
Myotonic dystrophy
Poliomyelitis (spinal)
Polymyositis/Dermatomyositis

Newborn and young children with bilateral lesions need ventilatory support.

Trauma cases can be considered for surgical repair (re-innervation may reach related muscles of the upper extremity, such that breathing discharges can be seen in EMG).

Adults: unilateral lesions may be compensated, but bilateral lesions may require nighttime respiratory support.

Dorsal scapular nerve

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<th>Imaging</th>
<th>Biopsy</th>
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**Fig. 24.** Dorsal scapular nerve anatomy. 1 Dorsal scapular nerve. 2 Levator scapular muscle. 3 Minor rhomboid muscle. 4 Major rhomboid muscle.
The dorsal scapular nerve arises from fibers of C4, 5 and travels through the medial scalene muscle and along the medial border of the scapula. This nerve is purely motor, and innervates the levator scapulae and rhomboid muscles (Fig. 24).

**Function:**
To elevate and adduct the medial border of the shoulder blade (together with the rhomboid muscles).

Almost no symptoms are reported, and usually only with powerful arm movements.

Atrophy of muscles cannot be seen. The scapula becomes slightly abducted from the thorax wall, with outward rotation of the inferior angle.

Neuralgic shoulder amyotrophy
Iatrogenic: operations
Nerve is sometimes used as a graft for nerve transplantations.

EMG
None

**Suprascapular nerve**

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<th>Genetic testing</th>
<th>NCV/EMG</th>
<th>Laboratory</th>
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<td>+</td>
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<td>MRI, US</td>
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Fibers mainly come from C5 and C6, and travel through the upper trunk of the brachial plexus to innervate the supra- and infraspinatus muscles. The nerve has no cutaneous sensory distribution (Fig. 25).

**Anatomy**

**Symptoms**

Dull, aching pain in the posterior aspect of shoulder, which is aggravated by arm use. The patient is unable to lie on his shoulder due to pain. Shoulder elevation and external rotation are weak. Also, slight atrophy of the muscles may be noted.
Muscle wasting.  
Lesion at the suprascapular notch: involvement of both muscles.  
Lesion at the spinoglenoid notch: only infraspinatus muscle impairment.

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<th>Signs</th>
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<tr>
<td>Abnormal transverse scapular ligaments (occasionally bilateral)</td>
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<td>Arthroscopic shoulder surgery</td>
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<tr>
<td>Closed trauma: the most common cause</td>
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<tr>
<td>Entrapment by the transverse superior or inferior ligaments</td>
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<tr>
<td>Neuralgic amyotrophy</td>
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<tr>
<td>Open trauma</td>
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<tr>
<td>Overuse: athletic activities (basketball, volleyball, boxing) or construction trades (e.g. carpentry)</td>
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<tr>
<td>Soft tissue masses: ganglion cysts</td>
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<tr>
<td>Surgery: arthroscopy</td>
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<tr>
<td>Systemic lupus erythematosus</td>
</tr>
<tr>
<td>Trauma: hematoma and fracture</td>
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<tr>
<td>Tumors: ganglion, cyst, metastasis</td>
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<th>Causes</th>
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<tr>
<td>Arthroscopic shoulder surgery</td>
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<tr>
<td>Closed trauma: the most common cause</td>
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<tr>
<td>Entrapment by the transverse superior or inferior ligaments</td>
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<thead>
<tr>
<th>Diagnosis</th>
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<tbody>
<tr>
<td>NCV of supraspinatus nerve</td>
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<tr>
<td>Needle EMG of muscles</td>
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<td>MRI, ultrasound</td>
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<tr>
<th>Differential diagnosis</th>
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<tr>
<td>C5 (C6) radicular lesion</td>
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<td>“Frozen shoulder”</td>
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<td>Rotator cuff tears</td>
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<tr>
<td>Tendinitis of the supraspinatus muscle</td>
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<td>Upper trunk brachial plexus</td>
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<td>Upper trunk brachial plexopathy</td>
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<th>Therapy</th>
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<tr>
<td>Depends on the etiology and severity.</td>
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<tr>
<td>Conservative: rest the limb, analgesics, activity modification, nerve block.</td>
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<tr>
<td>Operative: nerve decompression at entrapment sites.</td>
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<td>Replacement surgery: if the lesion appears to be permanent, a transfer from the horizontal part of the trapezoid muscle can be considered.</td>
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<th>Prognosis</th>
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<td>Depends on the etiology</td>
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<th>References</th>
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Subscapular nerve

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**Fig. 26.** Subscapular nerve anatomy. 1 Upper trunk. 2 Posterior cord. 3 Subscapular nerve. 4 Subscapular muscle. 5 Teres major muscle
Nerve fibers arise from C5 and C6, and travel through the upper trunk and posterior cord of the brachial plexus. The nerve innervates the subscapularis and teres major muscle, to secure the shoulder joint and provide inward rotation of the shoulder (Fig. 26).

Compensation for the function of both muscles is provided by the pectoralis major, latissimus dorsi, and anterior deltoid muscle.

Upon securing shoulder joint, an outward rotation of the upper arm. Atrophy is not visible, and there are no sensory findings.

Involvement either in association with radiculopathies or with posterior cord brachial plexus injury. There are no entrapment lesions.

EMG of the teres major muscle

C5/C6 radiculopathy, posterior cord lesion of the brachial plexus

Conservative

Anatomy

Symptoms

Signs

Pathogenesis

Diagnosis

Differential diagnosis

Therapy
### Long thoracic nerve

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Fig. 27. Long thoracic nerve anatomy. 1 Long thoracic nerve. 2 Serratus anterior muscle
Fibers stem from the ventral rami of C5–7, and travel through the dorsal part of the plexus. The nerve traverses the middle scalene muscle, and then passes below the brachial plexus on the thoracic wall. The nerve contains motor fibers exclusively for the serratus anterior muscle (Fig. 27).

Dull ache in the shoulder, affected shoulder seems lower, weakness of arm abduction, no sensory abnormalities.

Atrophy with scapular winging (Fig. 28)
Restriction of abduction and flexion of the arm above shoulder level.

**Infection:**
Lyme disease, typhoid fever

**Inflammatory-immune mediated:**
Neuralgic amyotrophy: seen mainly in association with other shoulder nerves, particularly with suprascapular nerve. Rarely isolated.

**Compressive:**
Pressure – part of Rucksack paralysis

**Iatrogenic:**
Intraoperative: thoracotomy, mastectomy, resection of the first rib, lymph node extirpation. Intraoperative positioning.
Trauma:
Acute trauma
Birth trauma
Blunt trauma
Motor vehicle accidents
Open injury
Sports: falls, football, wrestling (traction forces), carrying weights, backpacks, plaster casting, extreme shoulder movements (hitting, punching)

Idiopathic:
No apparent reason

Diagnosis
NCV: recording either with needle or surface electrodes
EMG
X-ray and CT: for all traumatic lesions

Differential diagnosis
Acute brachial neuropathy
Multifocal motor neuropathy
Muscular dystrophy
Root lesions C5–C7
“Sprengel” syndrome (hereditary shoulder elevation)
Upper limb predominant, multifocal chronic inflammatory demyelinating polyneuropathy
Winging of scapula is encountered in several conditions

Therapy
Conservative:
Trauma: neurapraxia, partial lesion (mild axonal lesion)
Blunt trauma
Neuralgic amyotrophy
Malpositioning

Operative:
Trauma: severe axonal lesion, neurotmesis

Prognosis
Generally good-partial lesions are common.

References
Thoracodorsal nerve

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<th>Genetic testing</th>
<th>NCV/EMG</th>
<th>Laboratory</th>
<th>Imaging</th>
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Fig. 29. Thoracodorsal nerve anatomy. 1 Thoracodorsal nerve. 2 Latissimus dorsi muscle
### Anatomy
Fibers stem from C5–C7 roots. (Only 50% of cases have fibers from C7.) The fibers pass through the upper and middle trunks and the posterior cord, and continues with the lower subscapular nerve.

Occasionally this nerve is a branch of the axillary and radial nerves.

A motor branch goes to the latissimus dorsi muscle, and may also innervate the teres major muscle.

Both muscles are adductors and inward rotators of the scapulohumeral joint and help to bring down the elevated arm (see Fig. 29).

### Symptoms
Few clinical symptoms, weakness compensated in part by pectoralis major and teres major muscles.

**Signs:**
- Atrophy, and slight winging of the inferior margin of the scapula
- Motor: Latissimus dorsi: weakness in adduction and medial rotation of shoulder and arm.

### Causes
Isolated lesion is very uncommon.

Neuralgic amyotrophy (rarely)

Plexus lesions: injury in association with posterior cord or more proximal brachial plexus lesions.

### Diagnosis
EMG

### Differential diagnosis
Plexus: posterior cord lesions, upper/middle trunk lesions

Radicular: C5–C7 lesion

### Therapy
Conservative. Surgical interventions are not necessary because of the minor dysfunction.

Due to this fact, this muscle can be used for grafting to the biceps brachii and outward rotators of humeroscapular joint.

### Prognosis
Good
Pectoral nerve

Patients note painless atrophy.  

Weakness and atrophy of the pectoral muscle. Compensatory hypertrophy of other chest muscles.  

Lateral pectoral nerve:  
Receives fibers from C5–7 (lateral cord of plexus) and supplies upper part of pectoral muscle.  

Medial pectoral nerve:  
Receives fibers from C8/T1 and supplies lower part of pectoral muscle.  

Aplasia  
Enterapment in hypertrophies of minor pectoral muscle  
Neck dissection  
Weight lifting  

Thoracic spinal nerves

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<th>Genetic testing</th>
<th>NCV/EMG</th>
<th>Laboratory</th>
<th>Imaging</th>
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**Anatomy**

The twelve pairs of thoracic spinal nerves innervate all the muscles of the trunk and surrounding skin, except the lumbar paraspinal muscles and overlying skin. Dorsal and ventral rami can be affected.

Three groups: T1, T2–T6, T7–T12.

a) T1 and C8: first intercostal nerve
b) T2–T6: innervation of the chest wall
   T2 is the intercostobrachial nerve (see also brachial plexus)
c) T7–11: Thoracoabdominal nerves
   T12 is the subcostal nerve

**Symptoms**

Pain, sensory symptoms, depending on whether dorsal or ventral rami are affected.

**Signs**

Muscle weakness may be difficult to assess, except in the case of abdominal muscles, where bulging occurs during coughing or pressure elevation.

**Pathogenesis**

**Metabolic:**
Diabetic truncal neuropathy

**Infectious:**
Herpes: Pre-herpetic neuralgia (1–20 days before onset)
   Herpetic neuralgia
   Post-herpetic neuralgia
Lyme disease

**Compressive:**
Abdominal cutaneous nerve entrapment
Notalgia paresthetica: involvement of dorsal radicular branches
Thoracic disc disease (rare)

**Neoplastic:**
Invasion at the apex of the lung
Schwannoma
Vertebral metastases

**Traumatic:**
Trauma
Iatrogenic:
Postoperative (abdominal surgery, post mastectomy, and thoracotomy)

Laboratory: Fasting glucose, serology (herpes, borreliosis)
CSF examination (e.g., pleocytosis and antibodies in Lyme disease)
Imaging: vertebral column: plain X-ray, CT, MRI
Electrophysiology: NCV of intercostal nerves is difficult and not routinely done.
EMG: paraspinal muscles, intercostals, abdominal wall muscles

Local painful conditions of the vertebral column (disc herniation, spondylodiscitis, metastasis)
“Intercostal neuralgia”
Muscle disease with abdominal weakness
Slipping rib/Cyriax syndrome

Depends on the etiology

Intercostal nerves

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<th>Genetic testing</th>
<th>NCV/EMG</th>
<th>Laboratory</th>
<th>Imaging</th>
<th>Biopsy</th>
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<td>(+)</td>
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<td>Osseous structures of vertebral column and ribs</td>
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**Anatomy**

The intercostal nerves are the ventral rami of the thoracic spinal nerves. They innervate the intercostal (first 6) and abdominal muscles (lower 6), as well as skin (via anterior and lateral branches). The first ventral ramus is part of the brachial plexus.

**Intercostobrachial nerve:**

Originates from the lateral cutaneous nerve of the second and third intercostal nerves to innervate the posterior part of the axilla. Often anastomizes with the medial cutaneous nerve of the upper arm (stemming from medial cord of brachial plexus). The 7–11th ventral rami are called the thoracoabdominal nerves. The 12th thoracic nerve is the subcostal nerve.

**Symptoms**

Radicular pain (beltlike)

**Signs**

Over the thorax cavity, no muscle weakness can be detected. However, bulging of abdominal muscles may be apparent.

**Pathogenesis**

Abdominal cutaneous nerve entrapment
Diabetic truncal neuropathy
Herpes zoster
Notalgia paresthetica
Post-operatively: abdominal, retroperitoneal, and renal surgery.
Traumatic lesions
Thoracic disc trauma (rarely)
Vertebral metastasis

**Diagnosis**

Laboratory: fasting glucose
Serology (herpes, Lyme disease)
Imaging: vertebral column, MRI
Electrophysiology is difficult in trunk nerves and muscles

**Differential diagnosis**

Pain may be of intra-thoracic, intra-abdominal, or spinal origin.
Compartment syndrome of the rectus abdominis muscle
Costochondritis
Head zones (referred pain)
Hernia
“Intercostal neuralgia”
Pseudoradicular pain
Rupture of the rectus abdominis muscle
Slipping rib
Thoraconeuralgia gravidarum

Depending on etiology

Therapy

References

Intercostobrachial nerve

Anatomy
Originates from lateral cutaneous nerve of second and third intercostal nerves to innervate the posterior part of the axilla. This nerve often anastomizes with the medial cutaneous nerve of the upper arm (from the medial cord of the brachial plexus).

Symptoms
Pain in the axilla, chest wall, or thorax. Often occurs one or two months after mastectomy. Reduced movement of the shoulder enhances pain.

Signs
Sensation is impaired in the axilla, chest wall, and proximal upper arm.

Differential diagnosis
Operations in the axilla (removal of lymph nodes)
Following surgery for thoracic outlet syndrome
Lung tumors

Reference
Iliohypogastric nerve

Fibers originate at L1, then emerge from the lateral border of the psoas, crossing the lower border of the kidney, then the lateral abdominal wall. Then the nerve crosses the transverse abdominal muscle above iliac crest and passes between the transverse and oblique internal abdominal muscles. Finally two branches are given off: the lateral anterior and anterior cutaneous nerves.

Burning and stabbing pain in the ilioinguinal region, which may radiate towards the genital area or hip. Symptoms increase when walking.

Difficult to examine. Spontaneous bulging of abdominal wall. Sensory deficit may be present. Tinel’s sign over a surgical scar may be observed. Slight flexion of hip while standing.

**Anatomy**

**Symptoms**

**Signs**
| Diagnosis | Electrophysiology is not routinely available. Clinical distribution. |
| Differential diagnosis | Spontaneous entrapment in abdominal wall, surgery, hernioraphy, appendectomy, abdominoplasty, nephrectomy, endometriosis. |
| Therapy | Steroids locally, scar removal, neurolysis. |
Ilioinguinal nerve

Fig. 31. Ilioinguinal nerve anatomy. a A-female. 1 Ilioinguinal nerve. b B-male. 1 Ilioinguinal nerve. 2 Ilioinguinal nerve

Fig. 32. Ilioinguinal nerve lesion after gynecologic surgery. The sensory loss (marked with a ball pen) reached almost the labia
The ilioinguinal nerve originates with fibers from T12 and L1. The motor component innervates the internal and external oblique muscles, and the transverse abdominal muscle. The sensory component covers the skin overlying the pubic symphysis, the superomedial aspect of the femoral triangle, the anterior scrotal surface, and the root of the penis/labia majora and mons pubis (Fig. 31).

Hyperesthesia, sometimes with significant pain over the lower abdominal quadrant and the inguinal region and genitalia (Fig. 32).

Weakness of lower abdominal muscles, hernia.

Abdominal operations with a laterally placed incision
Biopsy
Endometriosis, leiomyoma, lipoma
Herniotomy
Iliac bone harvesting
Pregnancy, child birth
Spontaneous entrapment – “inguinal neuralgia”

Studies: no standard electrophysiologic techniques are available

Local anesthetic infiltration
Surgical exploration and resection of the nerve

Genitofemoral neuropathy
Inguinal pain syndrome
Iliohypogastric neuropathy
L1 radiculopathy (very rare)

Genitofemoral nerve

The nerve originates from the ventral primary rami of L1 and L2, then runs along the psoas muscle to the inguinal ligament. In the inguinal canal the genital branch runs with the ilioinguinal nerve, to supply the skin of the mons pubis and labium majus. The genital branch also innervates the cremaster muscle, while the femoral branch innervates the proximal anterior thigh.

May give rise to continuous pain, sometimes called “spermatic neuralgia”. Can present as a post-operative inguinal neuralgia. Paresthesias (may be painful) of the medial inguinal region, upper thigh, side of scrotum, and labia majora.

Tenderness in the inguinal canal. Cremaster reflex unreliable.

Appendectomy
Bone graft removal
Hernioraphy
Nephrectomy
Trauma
Tumors (uncommon)
Tuberculosis
Varicocele testis

No electrophysiologic studies are available
Diagnostic anesthetic blockade

L1, 2 radiculopathy
Iliohypogastric neuropathy
Ilioinguinal neuropathy

Anesthetic blockade
Operative neurolysis

Good

Superior and inferior gluteal nerves

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**Fig. 33.** Superior gluteal nerve anatomy.

**Fig. 34.** Trendelenburg’s sign, indicating weakness of the hip abductors (gluteus medius muscle). 

**A** Standing on both feet the pelvis remains in horizontal position. 

**B** When the patient stands on his left leg, his pelvis tilts to the right side. This patient had a left gluteus medius nerve lesion, caused by an iliac aneurysm. Note that the greater gluteal muscles are not affected.
Superior gluteal nerve:  
Originate with the posterior branches from ventral rami of L4–S1, to innervate the gluteus medius and minimus muscles.

Inferior gluteal nerve:  
Originate with the posterior portions of L5 and S1, and ventral primary rami of S2. It innervates the piriformis and gluteus maximus muscles.

Superior:  
Causes Trendelenburg’s gait. Excessive drop of the non-weight-bearing limb and a steppage gait on the unaffected side. Hip abduction is weak, sensation is normal.

Inferior:  
Causes buttock pain and weak hip extension (weakness getting up).

Superior:  
Misplaced injection, trauma, hemorrhage, arthroplasty, aneurysm.

Inferior:  
Rarely isolated, often associated with the sciatic nerve, occasionally with pudendal nerve. Colorectal carcinoma, injections, trauma.

EMG, imaging

Sacral plexus lesion

Hip and pelvic pathology

Fig. 35. Pudendal nerve anatomy. a 1 Pudendal nerve. 2 Perineal nerves. 3 Dorsal nerve of clitoris. 4 Inferior rectal nerves. b 1 Perineal nerves. 2 Pudendal nerves
Fig. 36. Pudendal nerve anatomy. 

**a** 1 Dorsal nerve of penis. 2 Pudendal nerve. 3 Perineal nerves. 

**b** 1 Perineal branch of cutaneous femoral posterior nerve. 2 Pudendal nerve. 3 Rectal inferior nerves. 4 Bulbospongiosus muscle. 5 External anal sphincter muscle.
Anatomy

The nerve originates from S2–S4, and passes through the sciatic foramen and pudendal canal. Its terminal branches are the inferior rectal nerve (innervating the levator ani, external anal sphincter muscles, and skin around the anus), the perineal nerve (innervating the external urethral sphincter muscles, bulbocavernosus, perineum, and dorsal aspect of scrotum/labia), and the terminal branch of the pudendal nerve (providing sensation to the clitoris, glans penis, dorsal region of the penis) (see Fig. 35 through 37).

Clinical picture

Perineal sensory symptoms, sexual dysfunction. Bilateral lesions may cause urinary or fecal incontinence, impotence/anorgasmia, and sensory disturbances.

Signs

Sphincter reflexes (anal, bulbocavernosus reflex absent)

Causes

Selective injury is rare

External compression:
Perineal, post-operative of hip fractures
Long bicycle rides
Suturing through sacrospinal ligament during colonoscopy

Stretch:
Straining during defecation
Childbirth

Pelvic fracture
Pelvic surgery

Fig. 37. Pudendal nerve anatomy. 1 Cutaneous femoris posterior nerve. 2 Labial/scrotal nerves. 3 Anococcygeal nerve
Hip dislocation
Intraarticular foreign body

Polyneuropathy
Radicular lesion (S2–S4)
Sacral plexus
Structural abnormalities of the pelvic floor or viscera

EMG of external anal sphincter
Bulbocavernosus reflex
Pudendal SEP
Anorectal manometry, urodynamic examinations
Imaging

Differential diagnosis

Diagnosis

References