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Review article

Neurological risks in scheduled spinal surgery

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ABSTRACT

Spinal surgery is a high-risk specialty with an ever-increasing patient volume. Results are very largely favorable, but neurologic damage, the most severe complication, may leave major sequelae, some of which can be life-threatening. Neurologic complications may be classified according to onset (per- vs. postoperative) and surgical site (cervical vs. thoracolumbar). The present paper provides quantitative data for the risks involved. Knowledge of these complications and their risk of onset is the best means of guiding prevention strategies. The spine surgeon is part of a multidisciplinary team, with the radiologist and electrophysiologist, which is able to identify risk factors preoperatively and diagnose neurologic complications per- or postoperatively.

Introduction

The number of patients undergoing spinal surgery is constantly increasing, for several reasons. On the supply side, the possibilities of care have grown with improvements in diagnostic techniques, imaging, methods of treatment, equipment and materials. Moreover, the media publicity given to these advances in spinal surgery has led to increased patient demand.

The increasing number and complexity of procedures increases the potential number of perioperative neurological complications. Onset may be at any stage of treatment, and complications may be classified by period of onset as well as by the underlying mechanism [1].

The present instructional course seeks to assess neurological risk in spinal surgery. Risk is inherent to any medical or surgical procedure. The surgeon must assess the risk/benefit ratio, which determines his or her responsibility. Orthopedic surgery is recognized by the public authorities, including the Health Authority, to be an "at-risk" specialty, and spinal surgery is one of the subspecialities with the highest rates of litigation. Spinal surgery is usually functional; the patient therefore needs clear information concerning the proposed procedure, including the risk of neurological complications. The risk/benefit ratio should be discussed with the patient, and informed consent obtained.

The surgeon should also be trained in risk prevention, which is part of the professional training program instituted under the French In-Service Development scheme (*Développement Professionnel Continu* [DPC]).

In a systematic review of the literature on complications in spinal surgery, Nasser et al. analyzed 105 articles. Of the 79,471 patients, 16.4% presented a complication of one type or another, and incidence was twice as high in thoracolumbar surgery (17.8%) as for the neck (8.9%) [2].

Neurological structures may be damaged via direct or indirect mechanisms. Direct causes comprise compression, traction, and laceration and avulsion. Indirect causes comprise ischemic phenomena induced by elongation or compression of medullary or radicular vascularization.

Neurological complications of spinal surgery may occur per- or postoperatively.

Peroperative complications

Patient installation

By precaution, positioning should be adapted to a much longer surgery time than planned. All possible compression and traction points on the face, trunk and limbs should be inventoried.

Ocular complications:

As well as corneal lesions, spinal surgery involves risk of neurological ophthalmic complications. Lesions may involve the occipital cortex, optic nerve or retinal nerve cells. Visual disorder or loss may complicate not only cervical but also thoracolumbar surgery. Incidence is increasing, although still very low; it is 10 times as great after surgery in prone position, but may also occur with lateral decubitus. The Scoliosis Research Society estimates the rate of ophthalmic lesions at 1%, with a 0.05–1% risk of loss of vision [3].

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Neurologic ocular lesions. Neurologic ocular complications may take the form of ischemic optic neuropathy, central retinal artery occlusion or cortical central loss of vision.

Ischemic optic neuropathy (ION) mainly implicates spinal surgery in prone position. Onset may be perioperative, associated with arteritis or not. It may be bilateral but is more often unilateral (in 70% of cases), with immediate visual loss in 19% of cases [4]. This highlights the role of systemic factors, which almost always underlie unilateral loss of vision, more than mere malpositioning. Prognosis is very often unfavorable, with unilateral and sometimes bilateral visual disorder or even definitive visual loss. Identified risk factors comprise more than 4l blood loss, more than 4 hours' hypotension, surgery time exceeding 7 hours and severe hypoxia.

Central retinal artery occlusion: resulting loss of vision is almost always irreversible. Occlusion follows direct compression of the eyeball. The resulting intraocular pressure comes to exceed intravascular pressure, causing arterial occlusion and irreversible retinal ischemia. More rarely, it may be due to an atheromatous embolus of carotid origin.

Cortical central loss of vision results from occipital lobe stroke and is usually bilateral. It is frequently due to embolism or hypoperfusion of the occipital cortex. Causes are very numerous, occurring in a context of cardiac arrest, prolonged shock or gaseous embolism. Rarer causes have been reported, including embolism during cervical osteotomy in a seated position [5]. Prognosis is favorable and most victims recover sight.

Prevention of ocular complications. The efficacy of treatments for visual disorders is low, whence the importance of prevention.

Positioning should be with the head raised, to minimize facial and periorbital edema. Eyeball compression must, obviously, be avoided. The surgeon should position the patient very carefully on a classical "horseshoe" headrest, preferably in foam, tailored to protect the eyes, nose and respiratory system; even better is the single-use Mayfield® headrest, with fixation by 3 skull pins, leaving the whole face and neck region entirely free and accessible throughout surgery.

A second important point is for the anesthesiology team to maintain stable hemodynamics. Finally, blood loss should be rapidly compensated during hemorrhagic procedures.

Neurologic compression of the limbs

Peripheral nerve lesions are among the most frequent perioperative complications [6]. Plexus and trunk lesions of the limbs are mainly due to malpositioning.

Brachial plexus elongation. Lesions of the brachial plexus occur in the axillary fossa between the first fixation on the cervical vertebrae and the second on the axillary fascia. It lies close to the clavicle, first rib and superior extremity of the humerus, which may all induce compression or elongation. As well as such purely mechanical phenomena, the brachial plexus may undergo a combination of mechanical and ischemic effects by hypoperfusion of the vasa nervorum. Prolonged hypovolemia and hypotension are also risk factors, aggravated by hypothermia [7] or comorbidities such as diabetes or alcoholism.

Any positioning may induce peripheral nervous damage, especially in the brachial plexus. The rate of neurological lesions due to defective patient positioning is 0.14% for all procedures taken together [8], with brachial plexus involvement in 38% of these. Upper-limb abduction exceeding 90° in prone position causes traction and compression between the clavicle and first rib. In lateral decubitus, the brachial plexus is compressed if the shoulder is not released forward but placed between the thorax and the operating table. In supine position, excessive retropulsion creates tension in the brachial plexus, especially if shoulder abduction exceeds 90°. On awakening, patients complain of pain in the shoulder concerned, irradiating into the supra-spinatus fossa. Motor and sensory impairment varies with the extent of elongation and compression and the length of surgery. Prognosis is usually favorable. Recovery takes several weeks to months and requires lengthy rehabilitation.

Truncal involvement. Nerve trunk involvement may affect all 4 limbs.

The ulnar nerve may suffer compression at the elbow, at the upper-limb pressure point. Median nerve involvement is rarer.

Peroneal nerve compression at the fibular neck is possible in any patient positioning, inducing simple paresthesia or severe motor impairment with drop foot.

Femoral cutaneous nerve involvement results in meralgia paresthetica following ventral decubitus with compression of the anterior superior iliac spine region. A prospective study reported 20% prevalence of femoral cutaneous nerve damage after spinal surgery [9]. In half of the patients, involvement was bilateral, secondary to compression of the framework supporting the anterior superior iliac spines. More rarely, there was neurological damage due to retroperitoneal hematoma or sustained during iliac crest graft harvesting. In 89% of cases, recovery was complete within 3 months [9].

Prevention of limb nerve-trunk lesions. Patient positioning is a key step and the responsibility of the surgeon. All possible compression and stretching points along the nerve trunks of the four limbs and brachial plexus should be checked. Each risk region should be palpated to ensure that it is free; if necessary, a protection should be fitted. The shoulders should not be unduly lowered in making the inferior cervical spine accessible, and any cervical traction should be moderate.

Neurologic risk according to surgical site

The approach to the spine and spinal contents obviously entails a risk of medullary and radicular lesion. This may occur with a direct approach to the vertebral canal, but also with the canal intact: there may be direct instrumental trauma, faulty implant positioning or faulty preparation of the implant site. Neurologic deficits may be induced by damage to peripheral neurological or vascular structures within the approach.

Cervical spine

Medullary lesions. All anterior and posterior approaches incur a risk of medullary lesion; incidence is estimated at 0.2 to 0.9% [10]. The identified risk factors are myelopathy, medullary atrophy or ossification of the posterior longitudinal ligament. Correction of severe kyphosis with release and extensive fusion and also major instability are further risk factors.

Prevention of these severe complications requires good medullary perfusion maintained by arterial pressure > 80 mm Hg. Excessive cervical spine flexion or extension is to be avoided. Certain authors recommend monitoring evoked potentials on transcranial electrical stimulation. Hilibrand et al. reported that, in cervical spine surgery, evoked motor potentials on transcranial electrical stimulation showed sensitivity and specificity of 100%, compared to respectively 100% and 25% for evoked somesthetic potentials [11]. At end of surgery, before closing the approach, it is strongly recommended to make a final check on the osteosynthesis, and the position of the graft or interbody implant; this should also be done immediately in case of change in evoked potentials.

Radicular lesions. Reported incidence varies greatly, from 0.2 to 3.2%, due to differences in study populations. Disc surgery is associated with the lowest risk, while medullary decompression for