

Neuraxial Anaesthesia Complications

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Introduction

Adverse events related to neuraxial anaesthesia techniques range from discomfort to disability and death [1]. That may be due to the technique itself or the administered drug, and may happen as early or delayed complications [2].

The presence of certain underlying medical conditions, such as psoriasis, diabetes, leukaemia or previous neurological diseases, are increased risk factors for more complications [3]. Even when many of them are due to anaesthetic techniques it should be also considered the influence of some other variables such as delivery [4] or the type of surgery, because the neurological deficits are very frequently explained by these factors, which are not by themselves directly linked to anaesthesia.

Sympathetic Blockade Related Complications

Hypotension and bradycardia

These are the most frequent immediate complications of spinal anaesthesia [2] due to preganglionic sympathetic blockade. Calculations have shown that incidence of hypotension cases ranges from 8 to 33%, depending on the parameters used to define it (systolic blood pressure, usually <80-90 mmHg) or on a 30% reduction of the initial systolic blood pressure [5,6].

Hypotension that occurs during neuraxial anaesthesia is one of the most important etiological factors for intraoperative nausea and vomiting [7]. Risk factors for hypotension in spinal anaesthesia are also considered the presence of hypertension, a systolic blood pressure greater than 120 mmHg, an advanced age (>40 years old), a high body mass index, an increased foetal weight, the spinal anaesthesia associated with general anaesthesia, a puncture level above L2-L3, the addition of phenylephrine local anaesthetic, the chronic alcohol consumption, the emergency surgery and a high blockade [1,8].

A blockade below T10 does not modify peripheral resistance because the sympathetic innervations of un-anaesthetized levels cause vasoconstriction [2].

Hypotension may be prevented with a good prehydration (colloid or crystalloid solutions), or may be eliminated by using small doses of vasoactive drugs such as ephedrine.

Bradycardia is a consequence from blocking heart-accelerating fibres (T1-T4) or from a decreased venous return [2]. There are

certain risk factors for the appearance of bradycardia: heart rate lower than 60 bpm, ASA I, beta-blockers, block level above T6, age under 50 years and longer PR interval [9].

High blockade

High blockade is the name given to the excessive spread of locking dermatome, and may occur both in spinal or epidural anaesthesia [1]. It is commonly shown as a spinal or subdural diffusion of local anaesthetic causing hemodynamic and respiratory effects.

Spinal total blockade is the full expression of high blockade, which is associated to total sympathetic blockade and respiratory arrest.

Puncture level and dosing are the most important factors determining the height of analgesia. Also the injection speed and the patient tall and age have a lesser influence into this [1].

Pregnancy considerably modifies the spread of local anaesthetics injected in spinal, epidural or subdural spaces. In these cases the volume of local anaesthetics administered must be consequently reduced.

The sensitive and sympathetic level of blockade is essential for

this. If blockade level surmounts T4 cardio accelerator fibres could be blocked, being its effects hypotension and bradycardia.

The symptoms of a high blockade are a difficulty for breathing and the numbness or weakness of upper extremities. Also nausea appear together with hypotension [1]. When blockade reaches cervical levels it happens together with hypotension, bradycardia and respiratory insufficiency, which should be treated applying assisted ventilation and orotracheal intubation.

Hypotension must be treated with intravenous liquids, trendelenburg position and vasopressor drugs [10]. Co-hydration is more efficient than pre-hydration and colloid solutions are also very effective for cardiac rhythm and blood pressure maintenance.

Bradycardia should be treated with atropine and ephedrine. In severe cases adrenaline is also recommended.

In pregnant women ephedrine breaks through the placental barrier, stimulates beta-adrenergic receptors and increases fetal acidosis but it doesn't happen phenylephrine [11]. Actually this issue is being studied because the different works haven't found significant differences between these two drugs in the fetal's Apgar. Administering a dose of local anesthetic subdural level or accidental intrathecal to perform an epidural or caudal intervention may cause bad consequences, i.e. high blocking or total spinal (when extended to cranial nerves) with symptoms and treatments described, until lock yields [7].

Heart arrest

Severe bradycardia and cardiac arrest are the most serious complications associated with spinal anaesthesia. They are most frequently present in general anaesthesia spinal blocks.

The incidence of heart failure has been significantly higher at subarachnoid anaesthesia after epidural [12] and vary according to different studies. Recently the incidence of cardiac arrest during regional anaesthesia is estimated at 2.73/10,000 patients [13]. Patients are usually healthy, ASA I or II, male and with an increased basal vagal tone. In most cases a higher level T2 sensitive is detected with bilateral mydriasis after the cardiac arrest.

The influence of cardioacceleradoras fibers has a crucial role in maintaining blood pressure and heart rate, so the high cord lock, the intravascular volume depletion or the insufficient fluid intake and the presence of deep sedation are considered as risk factors.

Surgery may also trigger bradycardia and cardiac arrest producing vagal shock or embolization. Treatment is based on atropine and ephedrine, and if no answers are detected adrenaline should be early administered [14].

Both heart failure and respiratory failure may be related to an inadvertent injection of the anesthetic solution to intravascular, intrathecal or subdural level during administration of epidural doses [15].

Survival rate is higher in patients with cardiac arrest observed during spinal anaesthesia compared to general anaesthesia [16].

Urinary retention

Spinal anaesthesia affects urination by blocking nerve fibers (S2-S4), as a consequence of which the patient does not feel the distended bladder or urinary urgency. In other words, it means an abolition of reflex micturition.

The distended bladder produces postoperative discomfort and if not resolved can lead to more serious complications such as permanent damage of the detrusor. Several studies indicate that the urology detrusor muscle function recovers after about 100 minutes to recover the sensory level in S2-S3 [17].

Urinary retention is a common complication in men older than 50 years with urological problems [18]. The incidence is higher in anorectal surgery, inguinal hernia, orthopedic surgery (hip), abdominal surgery and gynecological surgery [19]. The use of additives to the local anesthetic such as opioids or epinephrine can increase the time for urination. Hydrophilic opioids contributed more in a meta-analysis to urinary retention than lipophilics [20].

Besides neuraxial anaesthesia, some intraoperative or anaesthesia-related factors prolong the time of anaesthesia or surgery, increase the volume of intraoperative fluids (>750 ml), the requirements of atropine, the drop in temperature and the use of opioids, which may also increase urinary retention [18,21].

Urinary catheterization is necessary in the perioperative or immediately after surgery.

Horner's syndrome

Horner syndrome has a variable incidence that sometimes goes unnoticed, being this a rare complication. It increases in epidural anaesthesia administered to pregnant patients, because their epidural space is reduced by engorgement of the epidural veins because of compression of the gravid uterus on the vessel [22].

This phenomenon is explained by the subdural local anesthetic spread from peridural space and is revealed when the preganglionic sympathetic fibers that innervate the iris dilator muscle, lift the upper eyelid, the conjunctiva and face are achieved and locked, producing miosis, ptosis and enophthalmos [23]. It is rarely associated with hypotension.

Drug Effects Related Complications

The incidence of systemic toxicity due to the local anesthetic is estimated at around 0.01%. It has been reduced significantly over the last 30 years, with peripheral nerve blocks, which are associated with a higher incidence [24-26] of toxic reactions is related to the anesthetic agent, adjuvants, injection rate, absorption and distribution, concentration and total dose of local anesthetic, as well as the route of administration and patient characteristics [27].

Local toxicity

The local toxicity covers a wide spectrum of manifestations, ranging from a localized allergic reaction to para-aminobenzoic acid (ester metabolite) to the myotoxicity and neurotoxicity [28].

Myotoxicity affects smooth and striated muscle in a dose-dependent way [29]. To discuss this issue it should be present a

persistent neurological damage, ruling out any trauma caused by needles.

This complication has been closely related to intrathecal administration of high concentrations lidocaine (5%), and to the use of a microcatheter [30].

Other local toxicity cases are transient neurological symptoms and transient radicular irritation, characterized by back pain radiating to the legs without sensory or motor deficits, which takes place after the resolution of spinal anaesthesia and disappears spontaneously after some days. The highest incidence occurs with the use of hyperbaric lidocaine, at men and on lithotomy position.

Systemic toxicity

Systemic toxicity ranges from neurological and cardiovascular symptoms to anaphylaxis. The central nervous system is more sensitive, so a lower dose and blood concentration of local anesthetic is required to produce toxicity effects [31]. Cardiovascular collapse can nevertheless occur without any previous neurological changes.

CNS toxicity is commonly described in two stages, that is, an excitatory initial phase followed by a phase of depression. Early symptoms include numbness of face or tongue, metallic taste and tinnitus, followed by confusion or agitation to reach generalized seizures afterwards. These symptoms are followed by a phase of depression with coma and respiratory depression.

Cardiovascular toxicity is described in three phases, that is, an initial phase with hypertension and tachycardia, a second one with myocardial depression and hypotension and a third one with deep intense vasodilation, hypotension and diverse arrhythmias such as sinus bradycardia, conduction blocks, ventricular tachyarrhythmias and asystole.

Anaphylaxis is rare and most commonly occurs with local anesthetics of amide ester type.

Methemoglobinemia is another complication that may appear after administration of prilocaine. Three cases from 1997 to 2007 have been described after administration of EMLA Cream (lidocaine made 25 mg/ml and prilocaine 25 mg/dl) used for laser hair removal [32-35]. The main clinical manifestation of acquired methemoglobinemia is cyanosis unresponsive to supplemental oxygen at high flow, although low saturation in arterial blood was confirmed [32]. In severe cases it was treated with intravenous methylene blue, obtaining a good response [36].

Needle/Cannula Placement Related Complications

Backache

The incidence of backache is approximately similar after spinal or general anaesthesia [37]. In fact, 25-30% of the patients undergoing general anaesthesia refer backache [1].

Investigators observed that the incidence of backache went from about 18% in surgeries lasting less than 1 hr to 50% when surgery lasted 4 to 5 hr [37]. As causes of this were highlighted

intervertebral disc injury, cutaneous haematoma, loosening of the paraspinal musculature lordosis, muscle spasm, an excessive administration of local anaesthetic in the epidural space, as well as the use of additional substances like EDTA to chloroprocaine in epidural anaesthesia [1,37-40].

These complications usually last some days or weeks, and treatment has to be based on non-steroidal anti-inflammatory drugs and cold or hot compresses. Even when this is a benign complication, it may also show an epidural abscess or haematoma [37], so the first to do is ruling out these serious complications.

The most important factor associated with back pain following a surgery is the duration of surgery, regardless of the used anaesthetic technique [37].

Dural puncture, subdural injection and post dural puncture headache (PDPH)

When small needles are used the normal incidence of PDPH is 0%-14.5% [41].

The cause of migraine is postpuncture CSF leakage from a dural defect and intracranial hypotension, which may occur following spinal anaesthesia or dural puncture after epidural needle when CSF outflow through Tuohy needle is evidenced. Postpuncture headache may also happen after an inadvertent dural puncture or by simply tearing dura with the needle without any LCR output [1].

It is widely known that needle design has dramatically reduced the risk of PDPH associated with spinal anaesthesia to about 1%. In a prevalence study by Lambert et al. [42] it was observed that the probability of PDPH was significantly lower when a 25G Whitacre needle was used in comparison with 27G Quincke, and absolute values required fewer blood patch treatment.

Thorbjon S. et al. [43] in a prospective study found that the incidence of PDPH was significantly lower with the use of non-cutting tip needles sprotte type or caliber 25G Whitacre in comparison with the use of 22G Quincke to perform diagnostic lumbar punctures, with a significantly lower rate of lost working days, hospitalization time and number of done hematological patches.

Hammond et al [44] also concluded that the use of smaller and non-cutting needles has a lower incidence of PDPH.

First line treatment for this are supine position, hydration, analgesics, corticotropin (54) and caffeine, even when if at 24-48 hr after initiation of treatment Tory has not submitted it is also needed the use of a blood patch with 10 ml of autologous blood [1].

A case has been also described of PDPH resolution after surgical repair of the dura [44].

Some other risk factors linked with postural puncture headache have also been found, apart from needle gauge, age, gender pregnancy, and bevel design or bevel orientation.

Diplopia and tinnitus is also related to intracranial hypotension. Diplopia has an incidence ranging from 1 in 400 to 1 in 8,000. The window period for extraocular muscles paralysis (EOMP)

to manifest is from 1 day to 3 weeks after dural puncture, but it most often happens 4 to 10 days after dural puncture. The exact pathophysiology is unclear, being the most generally accepted mechanism a nerve lesion such as neurapraxia or axonotmesis caused by stretch and/or compression secondary to intracranial hypotension due to cerebrospinal fluid (CSF) leakage. The main damaged structure is the VI cranial nerve, but can coexist with oculomotor nerve (cranial nerve III) or trochlear nerve (cranial nerve IV) palsies.

It is unilateral in 80% of cases. Errors often occur at the time of diagnosis, especially when diplopia appears after the resolution of PDPH box. It is to be noted dural puncture because of diplopia, and history must be examined because sometimes you can fall into a misdiagnosis as pachymeningitis or diagnostic lumbar punctures causing further hypotension and worsen the neurological picture made.

Treatment of headache postpuncture with blood patch does not interfere in the evolution and prognosis of diplopia. This treatment is conservative, recovering from 2 weeks to 8 months [45-49].

Neurological complications

It has been repeatedly detected that needle trauma and local anaesthetic neurotoxicity are at the origin of most neurological complications [50].

Brull et al. reported that the incidence of permanent neurological injury following spinal anaesthesia varied between 0-4.2 per 10000 patients [51]. It should be ruled out first a hematoma or epidural abscess [1].

In a French survey the incidence was nearly half the amount in obstetric patients compared to the non-obstetric population [52]. Direct needle trauma appears here to be one of the preventable reasons for neurological complications [53].

Auroy et al. and Moen et al. reported that direct needle or catheter-induced trauma rarely results in permanent or severe neurological injury. In fact there is a lower frequency of persistent paresthesia/radiculopathy following epidural techniques, which are typically associated with (epidural) catheter placement, compared to single injection spinal anaesthesia [12,50,54].

Auroy et al. also observed that two-thirds of the patients with neurological complications experienced pain during needle placement or injection of local anaesthetic.

It is very convenient to withdraw the needle in the case of paraesthesia to avoid postoperative radiculopathy.

Repeated local anaesthetic injection should also avoid in order preventing toxic concentrations in the spinal cord [53,54].

Conus medullaris injury

The chances of cauda equina or spinal puncture are low if it is assumed a puncture below L3.

Moen et al. [55] reported that the procedurals had presumed a level of insertion under L1 in all cases of conus medullaris injury. In obese patients or at the obstetric area it is not easy to determine

the Tuffier's line. Therefore Reynolds et al consider that Tuffier's line as unreliable to identify the correct intervertebral level.

Direct injection into the spinal cord can cause paraplegia. Medullary cone damage may result in cauda equina syndrome with sensory deficits and bowel and bladder disorders [1].

It is not sure nevertheless that the use of an ultrasound guide decreases would in any way these complications [56].

Neuroaxial anaesthesia and neurological conditions

Pre-existing spinal pathology or diseases like multiple sclerosis, amyotrophic lateral sclerosis, post poliomyelitis condition or the Guillen Barre syndrome mean an increase of the incidence of postoperative neurological complications following neuroaxial blockade [52].

Mechanical trauma, toxicity by local anaesthetics, neural ischaemia due to additives and also stress may worsen the patient's neurological status. The last one of these factors may produce confusion with a procedure caused neural injury. The benefit-risk of locoregional anaesthesia versus general anaesthesia must nevertheless be valued, not considering this an absolute contraindication [57,58].

Multiple sclerosis

Multiple sclerosis is a central nervous system demyelinated neurological condition in which it has been detected the existence of a disruption in the number and distribution of sodium channels, altering nerve conduction.

A series of oligopeptides in the cerebrospinal fluid with blocking activity of sodium channels have been isolated, acting as local anaesthetics do and being responsible for the negative symptoms of the disease [59].

Indirect evidence suggest that systematically administered intravenous local anaesthetics may unmask silent demyelinated plaques, transiently producing symptoms. It has been discussed the use of this method as a test for early diagnosis of MS [60]. However, local anaesthetics can improve positive symptoms such as spasticity and paresthesias by blocking ectopic impulses that cause it, being intravenous lidocaine a treatment option for these positive symptoms [61]. It seems that there's an increase in the duration of spinal anaesthesia, and increased relapse more relative to a stress such as surgery or postpartum with the anesthetic technique itself [62].

Dalmas et al. suggest that epidural anaesthesia is innocuous in this context [63], so the previous diagnose of these neurological condition is not a contraindication for epidural or spinal anaesthesia. The final decision has to be taken by both patient and doctor anyway.

Spinal or epidural haematoma

Spinal haematoma following spinal anaesthesia is a severe complication that requires early surgical intervention to prevent permanent neurological damage [64]. Incidence cases are about 1:150.000 in epidural anaesthesia and above 1:200.000 in spinal anaesthesia, tending to increase [64]. This is more frequent at epidural anaesthesia or catheter placement because

of the increased vascularity of epidural space in patients with coagulation disorders, and also at the presence of anticoagulant or antiagregant drugs, female gender or advanced age factors [1,64].

Symptoms are caused by direct compression and ischemia of the spinal cord or spinal nerves, being acute legs or backache, motor weakness and dysfunction of sphincters the most important of them. Epidural or spinal haematoma CT or preferably MRI should be implemented. Functional recovery after spinal descompression is possible when this is performed into the first 8 or 12 hr after puncture.

Spinal anaesthesia seems to be safe in patients suffering known bleeding disorders, according to monitored coagulation status. Even when there is no consensus about a safe count, 50.000 to 80.000 platelets number is generally considered as critical for pinal or epidural anaesthesia [65].

Meningitis and epidural abscess

Bacterial infection of the central neuraxis may appear as meningitis or cord compression secondary to abscess formation [66].

Bacterial meningitis is a medical emergency. Mortality reaches about 30% even when antibiotic therapy is applied.

Meningitis after a neuraxial block is a rare but eventually serious effect that might happen as a consequence of an unintentional chemical inoculation of microorganism (virus or bacteria) or chemical into the cerebrospinal fluid. Incidence is low (about 0 to 2 cases every 10,000 procedures) and only 30 of these cases are considered at bibliography [67].

The presence of fever and neurologic disturbance may provide a differentiation from PDPH [64].

Postanesthetic spinal meningitis may be classified etiologically in septic, aseptic and viral [68]. Bacteria are produced first.

Diverse cases have been described: *Staphylococcus aureus*, *Enterococcus faecalis* [67], *Pseudomonas aeruginosa*, *Streptococcus agalactiae* and *Listeria monocytogenes* [68].

Streptococcus viridans is the most common agent. It doesn't usually appear in humans, unless local or general, spontaneous or iatrogenic immunosuppression occurs.

Streptococcus salivarius, belonging to viridans group, causes more than a 60% of iatrogenic meningitis and more than a 90% of the bibliographically described spinal meningitis postpuncture [67]. This is a regular guest of skin, oral cavity and gastrointestinal tract, genitourinary tract and sinuses, with a predilection for tongue surface and saliva. Clinical picture may appear with meningismus classic signs.

CSF appears as turbid with predominantly polymorphonuclear pleocytosis, elevated protein and glucose reduction to a 40-

50% of blood glucose. GRAM and culture show bacterial growth (sensitivity of 80% for bacterial culture).

Aseptic meningitis is caused by an inflammation of meninges through various mechanisms, such as injection into the subarachnoid space of foreign bodies or detergents, chemical reactions to the components of the injected drug mixture, traumatic puncture, or aggravation of systemic known or neurological disease such as multiple sclerosis. There are reports about cases produced by systemically administered NSAIDs, as ranitidine or carbamazepine drugs [68], clinically manifested by symptoms as fever, headache occipital location, photophobia, confusion, altered level of consciousness and neck stiffness with signs of meningismus. They usually have good prognosis and are self-limiting.

LCR is characterized by the presence of a predominance of polymorphonuclear leukocytosis, elevated protein and normal or low glucose [68].

It may be easily seen that these biochemical alterations are not far from the ones found in septic bacterial meningitis. Therefore it is convenient to be sure of the absence of microorganisms in the GRAM and culture to opt for aseptic meningitis. Nevertheless it may happen that patient received prophylactic antibiotic treatment perioperatively to prevent us from ensuring that there is beheaded septic meningitis.

Viral meningitis after neuraxial techniques are usually benign course ones, being the lowest ones in frequency. There are reports of coxsackie B virus [67]. The optimal skin preparation for neuraxial procedures is 0.5% chlorhexidine in 70% alcohol. Concentrations above 0.5% may not be supported: they are evidently effective, but would eventually increase the risk of neurotoxicity coming from inadvertent contamination, and therefore should be avoided [69].

There are some considerations about the febrile and bacteriemic patient, not being absolute indications anyway. Despite conflicting results many experts suggest that central neuronal block should not be performed in patients with untreated systemic infection, excepting most extraordinary circumstances. The available data however suggest that patients with evidence of systemic infection may safely undergo spinal anaesthesia, provided that appropriate antibiotic therapy is initiated before dural puncture and that patient has shown a response to therapy, such as a decrease in fever (placement of an indwelling epidural (or intrathecal) catheter in this group of patients remains controversial) [70,71].

Conclusions

Spinal anesthesia is a safe anesthetic technique. However the complications and the need for its early treatment can have a major impact on the patient. The knowledge of them, addressing early (usually the most important prognostic factor in its evolution) and the need to take steps to avoid them is necessary.

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