French clinical guidelines for peripheral motor nerve blocks in a PRM setting

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Alain P. Yelnik[1], Claire Hentzen[1], Philippe Cuvillon[2], Etienne Allart[3], Isabelle V. Bonan[4], François C. Boyer[5], Flavia Coroian[6], François Genet[7], Thibaud Honore[4], Marylène Jousse[1], Dominique Fletcher[8], Lionel Velly[9], Isabelle Laffont[6], SOFMER group, SFAR group, Eric Viel[2,]

Corresponding author Alain P. Yelnik
alain.yelnik@aphp.fr

1 PRM Department, Paris Diderot University, GH Saint Louis – Lariboisière – F.Widal, AP-HP, 200 Rue Fbg St Denis 75010 Paris France

2 Anesthesia and intensive care Department, Carémeau University Hospital, 30000 Nîmes, France

3 Neurorehabilitation Unit, Lille University Medical Center, 59000 Lille, France

4 PRM Department, University Hospital; Faculty of Medicine, University of Rennes 1, 2 rue Henri le Guilloux 35000 Rennes France

5 PRM Department, Reims Champagne Ardenne University, Sebastopol Hospital, 48 rue de Sebastopol, 51092 Reims France

6 PRM Department, Montpellier University Hospital, Euromov, IFRH, 34000 Montpellier France

7 PRM Department, Versailles St. Quentin University, R.Poincaré Hospital 92380 Garches France

8 Anesthesia Department Ambroise Paré Hospital, AP-HP, 9 avenue Charles de Gaulle 92100 Boulogne Billancourt France

9 Anesthesia and Intensive Care Department - CHU Timone - Institut de Neurosciences de la Timone - UMR 7289, Marseille France

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SOFMER group:

Etienne Allart, Isabelle Bonan, François Constant Boyer, Flavia Coroian, François Genet, Claire Hentzen, Thibaud Honore, Marylène Jousse, Isabelle Laffont, Alain Yelnik.

SFAR group:
Olivier Choquet (Montpellier), Philippe Cuvillon, Dominique Fletcher, Valeria Martinez (Paris), Lionel Velly, Eric Viel, Hervé Quintar, Marc Garnier (Paris).

1. Conceptualization: Philippe Cuvillon, Isabelle Laffont, Eric Viel, Alain Yelnik,
2. Data curation : Etienne Allart, Isabelle Bonan, François Constant Boyer, Flavia Coroian, François Genet, Claire Hentzen, Thibaud Honore, Marylène Jousse, Isabelle Laffont,
3. Formal analysis: Etienne Allart, Isabelle Bonan, François Constant Boyer, Flavia Coroian, Philippe Cuvillon, François Genet, Claire Hentzen, Thibaud Honore, Marylène Jousse, Alain Yelnik,
4. Investigation : Etienne Allart, Isabelle Bonan, François Constant Boyer, Flavia Coroian, François Genet, Claire Hentzen, Thibaud Honore, Marylène Jousse, Isabelle Laffont.
5. Methodology: Philippe Cuvillon, Alain Yelnik,
6. Project administration: Isabelle Laffont, Alain Yelnik,
7. Resources: Isabelle Laffont, Alain Yelnik,
8. Supervision: Eric Viel, Alain Yelnik
9. Validation : Etienne Allart, Isabelle Bonan, François Constant Boyer, Olivier Choquet, Flavia Coroian, Philippe Cuvillon, Dominique Fletcher, Marc Garnier, François Genet, Claire Hentzen, Thibaud Honore, Marylène Jousse, Isabelle Laffont, Valeria Martinez, Hervé Quintar, Lionel Velly, Eric Viel, Alain Yelnik.
10. Writing – original draft: Etienne Allart, Isabelle Bonan, François Constant Boyer, Flavia Coroian, François Genet, Claire Hentzen, Thibaud Honore, Marylène Jousse.
11. Writing – review & editing: Isabelle Laffont, Eric Viel, Alain Yelnik,

Abstract

Introduction: Motor nerve blocks with anesthetic drug for local anesthesia are commonly used in Physical and Rehabilitation Medicine (PRM), especially in the field of spasticity. Guidelines in this context are currently lacking.

Method: Eighteen experts selected on the basis of their recognized experience by the scientific committees of the French PRM (SOFMER) and Anesthesia and Intensive care (SFAR) societies were invited to work and propose guidelines for the use of loco-regional anesthetic drug for motor nerve blocks in PRM setting. Eight issues were addressed: which neural blocks for which indications; drugs and contra-indications; medical survey and attitude in case of adverse event; injection and guidance material; patient preparation and pain relief; efficacy assessment; patient information; education of PRM physiatrists. The Medline, Cochrane and Embase databases for the period 1999 to 2018 were consulted and 355 papers analyzed. The drafts were commented then approved by the whole group using electronic vote, before final approval by scientific committee of each society.

Results: No scientific evidence emerged from the literature. Thus, these guidelines are mainly based on the opinion of the expert panel. Guidelines for each issue are reported with the main points of arguments. The main question deals with the recommendation about doses for each drug: for lidocaine -up to 2 mg/kg- "check contra-indications, emergency truck available, no need of previous anesthetic consultation nor presence of anesthetic physician"; for ropivacaine -up to 1.5 mg/kg, with a maximum of 100 mg- the same but after intravenous line. Beyond these doses, SFAR guidelines have to be applied with the need of anesthetic physician.

Conclusion: These are the first organizational guidelines devoted to increase the security of motor nerve block use in PRM settings

Peripheral motor blocks with anesthetic agents have been used in physical medicine and rehabilitation services for many years. Based on the principles of loco-regional anesthesia, they consist of the targeted injection of an anesthetic agent to temporarily suppress the action of a given muscle group. The purpose of the procedure is both diagnostic and prognostic, making it possible to obtain in a transient and reversible way the effect of the blockage of musculo-nervous conduction on one or more target muscle(s).

To date, the absence of recommendations and the fear of accidents involving anesthetic agents could hinder the practice, despite legislation permitting any doctor to perform the procedures for which they have been trained. To our knowledge, this study is the first to propose guidelines for the achievement of motor nerve blocks in clinical practice of Physical Medicine and Rehabilitation (PRM). These formalized recommendations are the result of the work of a group of experts convened by the French Society of Physical Medicine and Rehabilitation Medicine (SOFMER) and the French Society of Anesthesia and Intensive Care (SFAR) that primarily worked on the safety conditions for the construction of engine blocks.

The subjects covered by these guidelines are as follows:
1. The blocks concerned and the indications
2. Products and contraindications
3. Medical /nursing presence and patient monitoring; what to do in the event of an incident
4. Injection and tracking equipment
5. Patient preparation and possible analgesia
6. Monitoring effectiveness
7. Patient information (form and content)
8. Training of the practicing PRM physician

Method:

These guidelines have been written thanks to a collaborative work between the two societies (SOFMER and SFAR) to adapt previous guidelines on loco-regional anesthesia written by the SFAR to the specific clinical practice in Physical and Rehabilitation Medicine.

Eighteen experts have been chosen by the scientific committees of both societies on the basis of their recognized daily experience in university departments. Each of the eight questions has been allocated to three or four experts. A systematic review of the literature was performed with two independent perusals in accordance with the Prisma guidelines (www.prisma-statement.org/). Scientific articles retained were in English or in French, added to French surveys, guidelines and regulation texts. The eligibility criteria were any articles on the subject of Motor blocks applied to patients followed in PRM departments for neurological disability. Single cases reports were only considered when reporting adverse effect. The Medline, Cochrane and Embase databases for the period 1999 to 2018 were consulted. The words sought in the titles, abstracts and keywords were: local anesthesia, motor block, spasticity, stroke, brain injury, spinal cord injury, spastic paresis. Finally, due to the amount of non-relevant references with the last keywords, only the three following were used: local anesthesia, motor block and spasticity or spastic paresis. Studies on phenol or alcohol blocks were not considered. 355 articles were screened among them 21 were retrieved (Fig 1). Results of the literature analysis have been presented and discussed during regular meetings or phone call by the whole group. The drafts for guidelines written for each question have been commented by the whole group before the final edition before submission

and approval by the whole group using electronic vote. Once approved by the group, the guidelines have been submitted to the scientific committee of each society for final approval.
Results: no scientific evidence could be raised from the literature, except the knowledge of adverse events according to the drug and their relation to the dosage. Then these guidelines are mainly based on the opinion of the expert panel. Result of the vote: for each question, expert has to quote from 1 to 9 his/her accordance with the guideline. To be approved, the percentage of notes 7, 8 and 9 had to be over than 50%. Among the 16 participants these percentages are given Table 1. Afterwards each scientific committee has voted unanimously the approval of these guidelines (SOFMER on 13 June 2018, SFAR on 26 October 2018).
Complete guidelines are published in this paper, with the main arguments, without the annexes. The complete text in French with guidelines and arguments, is available on the SOFMER web-site www.sofmer.com.

1. Which are the motor nerve blocks concerned and for which indications?

Recommendations

1.1 Motor blocks may be used in patients with neurological impairment, involuntary muscle spasticity or hyperactivity to specify therapeutic strategy.
1.2 There is no comprehensive list of targets for motor nerve blocks.
1.3 There is no argument in the literature to discourage the creation of certain motor nerve blocks (all motor or mixed nerves can theoretically be the subject of a motor block).
1.4 Selective blocks (distal motor branch) should be prioritized, allowing for finer clinical analysis, a lower dose of local anesthetic and a result closer to that obtained with sustainable therapy (phenolization, neurotomy, botulinum toxin injection).

Rationale

Motor nerve blocks are intended for patients with motor disorders related to central nervous system disorders, regardless of the cause. The most common disorder is spastic paresis, which combines three components: voluntary control disorder (paresis), involuntary muscle hyperactivity called spasticity in its broadest sense (exaggeration of the stretching reflex, agonist-antagonist co-contractions, spastic dystonia) as well as soft tissue changes, contractile properties and muscle stretching, with a risk of shortening the muscle.
This spasticity can induce deformities at rest, sources of pain, maceration or aesthetic discomfort, on the one hand, and functional discomfort during movement, on the other. It is not always easy to distinguish the mechanisms responsible for the patient's discomfort. It is in this context that motor blocks have been used for many years in PRM to evaluate and guide therapy in neurological patients with complex spasticity (1-20).
Motor nerve blocks are used to differentiate between spastic hypertonia and musculotendinous contracture when the clinical examination has not resulted in a decision. In fact, the detection of muscle contracture by the motor blocks can lead to the indication of an associated neuro-orthopedic surgical procedure, and makes it possible to decide on the irreversible procedures to be performed, particularly concerning the soft parts (elongation or tendon transfer) (1).

They also allow for a transient functional clinical evaluation of the effects of neurolysis or a botulinum toxin injection prior to treatment. This is indeed durable (several months for botulinum

toxin or chemical neurolysis) or even permanent (surgical neurolysis). Therefore, in patients with a weak motor control, this evaluation is essential to judge the interest of carrying out the treatment and not to risk aggravation. Mechanisms to compensate for a motor deficit may exist, for example at the lower limbs for mobile patients. Spasticity can then be useful for this purpose.

Also for example, several studies have shown a good correlation between the results of tibial nerve block (+/- selective) and those of selective neurotomy or injection of botulinum toxin into the sural triceps (2,3). The blocks also allow to better define the therapeutic objectives with the patient. In their cohort of 815 motor nerve blocks, Filipetti and Decq (1) showed their benefit to reach a therapeutic choice: screening of agonist muscles with study of their voluntary motor skills, evaluation of the spasticity angle via pre and post block Tardieu scale, functional test for the patient during a new motor balance.

In practice, all peripheral nerves, motor or mixed, can be targeted depending on clinical symptomatology. Tables 2 and 3 provide a non-exhaustive list of the most common indications.
The amount of local anesthetic used to block a nerve stem is determined by several factors. It decreases with the diameter of the nervous trunk approached. The use of distal blocks is preferred because it limits the amount of local anesthetic administered (21).

2. Products and contraindications

Recommendations

2.1 Choice and dosage of anesthetic agent
2.1.1 For the achievement of PRM motor nerve blocks, it is recommended to use lidocaine because of its lower toxicity (local or general). If a prolonged effect is desired, ropivacaine can be used.
2.1.2. Adrenalized forms have no indications regarding the practice of PRM motor nerve blocks.
2.1.3 The use of other anesthetic agents is not recommended.
2.1.4 Recommended Doses: It is recommended to use the lowest possible doses (see 1.4). According to professional agreement, the following precautions may be recommended:
Level 1 precautions:
- for lidocaine doses (up to 2 mg/kg): check for contraindications, emergency truck nearby (contained in Appendix 1), no pre-anesthetic consultation, an anaesthetist is not required.
- for doses of ropivacaine (up to 1.5 mg/kg, with a maximum of 100 mg): same as above, but with a preliminary intravenous line.
Level 2 precautions for higher doses (>2 mg/kg Lidocaine; > 1.5 mg/kg or > 100mg ropivacaine), it is recommended to take the precautions published by the French Society of Anesthesia and Intensive Care (SFAR) (in particular: intravenous line, monitoring, emergency truck, immediate availability of an anesthetist resuscitator).

2.2 Time to be strictly observed between 2 blocks: The time interval between two successive injections (reaching the maximum dose) must not be less than the half-life of the agent in question, i.e. 60 minutes for lidocaine and 180 minutes for ropivacaine.

2.3 Procedure in case of anticoagulant and anti-aggregating (antiplatelet drug) treatment
2.3.1 The pursuit of anti-aggregating agents when achieving a block is not contraindicated but must be assessed on a case-by-case basis depending on the agent (aspirin vs. other agents), the terrain, and the type of block.
2.3.2 For patients on anticoagulant therapy, it is recommended:
- not to take the risk of stopping an effective anticoagulant treatment (Antivitamin K, Direct Oral Coagulants or Heparins) for a non-vital procedure.
- to take into account the risk of an hematoma and the risk of potential complications to this hematoma, in particular the occurrence of compartment syndrome.
- to distinguish between low-risk blocks (single, superficial puncture etc.) and high-risk blocks (deep, multiple injections etc.), in order not to perform the latter in the event of effective anticoagulation.
- for low-risk blocks performed under AVK: the block can be performed when the international normalized ratio (INR) is <3, with an emphasis on the use of ultrasound detection techniques.

Rationale

The motor nerve blocks are made with local anesthetic drugs, although the objective is not to obtain an anesthesia. These recommendations concern the choice and contraindications of anesthetic drugs, as well as contraindications related to the procedure itself and the technique. In 2003, the SFAR and the French Speaking Society of Emergency Medicine (SFMU) have published recommendations for the practice of blocks by non-anesthetist physicians. Given the similarity of the problem, the French Society of Physical and Rehabilitation Medicine (SOFMER) and SFAR recommend the application of the same recommendations and arguments (21).
We only mention some basic data here.

Pharmacokinetic recall and intervals between two injections
Amide local anesthetics are differentiated according to their strength. Low-power local anesthetics (lidocaine, prilocaine and mepivacaine) have a short action onset (5 to 10 min depending on the site) and an onset of action of 1h 30 to 2 h. The most potent local anesthetics (ropivacaine and bupivacaine) have a longer onset of action. Systemic resorption is a step in their elimination, allowing their subsequent metabolism. The metabolism of local anesthetics of the amide type is exclusively hepatic, through the cytochrome P450 system, and depends on the hepatic blood flow. The speed with which the local anesthetic appears in the blood depends on the injection site. The onset is faster in well vascularized cephalic areas than in the lower limbs. Caution should be exercised when reinjecting local anesthetics, even if spaced, due to the toxic risk of cumulative doses. In order to protect against the risk of an overdose, it is necessary to take into account the disposal half-life of each product.

Toxicity
Local toxicity
Local anesthetics, and more particularly lidocaine, are toxic to the nerve. However, this toxicity only occurs during spinal anaesthesia, which is outside the scope of these recommendations or

during accidental into the nerve injection. Neurological complications associated with local anesthesia are related to trauma or ischemic compression nerve damage. A neurological lesion prior to the procedure must be investigated, diagnosed and documented before the local anesthesia is performed. Local anesthetics and bupivacaine in particular, can cause a toxic muscle injury characterized by a disruption of calcium and mitochondrial metabolism. Intramuscular injection is not recommended in patients with mitochondrial pathology and in professional athlete.

Systemic toxicity

The concentration of a local anesthetic likely to cause systemic accidents is inversely proportional to the power of the agent used. For a given agent, toxicity is a function of its plasma concentration, which may be increased by accidental injection into a vessel, by a single dose that is too high, or by cumulative doses that are too high.

It is common practice to recommend the total cumulative doses of local anesthetic not to be exceeded. This must be qualified because the danger lies more in the accidental intravascular injection than in the resorption proportional to the total dose administered. In practice, the maximum doses for adults are 300 mg for lidocaine and 150 mg for ropivacaine. These are absolute figures that must be adapted according to the injection site and the terrain. In practice, 5 ml (50 mg) injected in contact with the nerve provides a deep motor block, but even lower doses can be used on distal trunks.

Central nervous toxicity

All agents may induce convulsive accidents. The neurological toxicity ratio of bupivacaine, ropivacaine and lidocaine is approximately 4/3/1, corresponding to the approximate power ratio of these agents. The neurological toxicity of local anesthetics results in prodromes (paresthesia, headache, malaise, dizziness, visual or auditory hallucinations), then convulsions; finally, in the final stage, in a coma with cardiorespiratory depression.

Cardiac toxicity

At toxic concentrations, local anesthetic slows down intraventricular conduction, which leads to functional conduction blocks. Arrhythmias with ventricular tachycardia, torsade de pointes or extreme bradycardia may occur. Hypoxia, acidosis, hypothermia, electrolyte disorders (severe hyponatremia or hyperkalemia) increase the risk of cardiotoxicity. Resuscitation of cardiac arrest following injection uses universally recommended techniques and intralipid administration (22).

The prevention of risks related to the systemic toxicity of local anesthetics requires the injection of low doses, compliance with maximum doses, a suction test performed before the injection and repeated during the injection, a slow and fractionated injection.

Rare cases of systemic toxicity have been described for low-dose injections such as in dental surgery. Sambrook (23) in 2011 reported 221 cases of systemic toxicity (neurological, cardiovascular, allergy, allergy, Methemoglobinemia) reported during locoregional dental anaesthesia between 1973 and 2008 to the Office of Product Review of the Therapeutic Goods Administration in Australia, with 11 million procedures performed per year. Prilocaine was the anesthetic most often involved in systemic reactions, accounting for nearly 70% of cases used alone or in combination compared to 23% for lidocaine. Dosages are not detailed.

Accident frequency in PRM

The literature review (4) concerning the achievement of motor nerve blocks in PRM contains 19 articles, mainly series of less than 50 cases and "case reports". No cases of systemic toxicity have been reported, including in large cohort studies such as the 815 blocks of Filipetti et al (1) and 146 blocks of Ghroubi et al. (16). A single case of “avulsion fracture of the calcaneum at the insertion of the Achilles tendon” has been reported (24).

Contraindications to anesthetic drugs

Contraindications to the use of local anesthetics are rare. Absolute contraindications are: proven allergy to an agent of the corresponding class (allergy to local anesthetics of the amide type is very exceptional), allergy to sulfites; first generation MAOI treatment for adrenalized forms; porphyria for lidocaine and ropivacaine; intravenous administration.

They should be used with caution in cases of: epilepsy, hypovolemia, atrioventricular block or conduction disorders, bradycardia or respiratory failure, severe liver failure.

Adrenaline forms have additional contraindications but have no indications in the practice of PRM motor nerve blocks.

Contraindications not related to anesthetic drugs

Contraindication to the detection technique: electrostimulation is not a contraindication in the case of Pacemaker and implanted automatic defibrillator but may impose an opinion and/or cardiologic control of the device (deprogramming).

Contraindications to peri-nervous injections: septic zone, acute or chronic polyradiculoneuritis. Particular attention should be paid in the event of associated pathology "considered to be at potential risk of aggravation": severe and progressive diabetic neuropathies when aggravating factors are added (renal failure, etc.); neuropathies related to chemotherapy; hereditary neuropathies; chronic diseases of the anterior horn, such as spinal muscular atrophy and poliomyelitis.

How to deal with patients undergoing antiplatelet and anticoagulant agent treatment:

The American Society of Pain Medicine and Regional Anesthesia, the European Society of Regional Anesthesia and Pain Management, the American Academy of Pain Medicine, the International Society of Neuromodulation and the World Institute of Pain have recently published recommendations on how to deal with platelet and anticoagulant drugs when performing different procedures (25). The peri-nervous injection of an anesthetic drug is classified as a low risk procedure for bleeding accidents.

The recommendations of the SFAR in 2016 (26) are based on the Recommendations of the French National Authority for Health (HAS) (27) on scheduled procedures requiring the interruption of AVKs (Antivitamin K) and specify the procedure to be followed with regard to direct oral anticoagulants.

The 2008 HAS Recommendations on “Scheduled Procedures Requiring Interruption of AVKs” (27) distinguish between procedures responsible for low-intensity, easily controlled bleeding that can be performed without interrupting AVKs and those requiring interruption of anticoagulant treatments. Low risk procedures include skin surgery, cataract surgery, some low risk rheumatology procedures, some oral surgery and some digestive endoscopy procedures. Peripheral nerve injections were not specifically mentioned.

In PRM, in the practice of motor blocks, often distal and involving deep nerve trunks, the group of experts proposes to consider the risk of the consequences of the occurrence of a hematoma: minimal in the case of a superficial hematoma, more significant in the case of a deep hematoma threatening a compartment syndrome. This risk must be taken into account in the benefit-risk balance. The first risk to be considered is the risk of discontinuation, even transient, of anticoagulant or anti-aggregating therapy, the second being complications of hematoma.

3. Medical supervision/the patient's nurse during and after the operation; what to do in case of an incident?

Recommendations

3.1 In all cases, the general precautions are:
- Presence of the physician during the operation and a nurse for post-block monitoring, the physician remaining nearby;
- A procedure to be followed in the event of a toxicity effect is directly accessible;
- Slow injection with regular control of absence of blood reflux at aspiration;
- Maintaining verbal contact with the patient;
- Surveillance of early signs of neurotoxicity and cardiotoxicity;
- Duration of monitoring: 30 minutes after lidocaine injection, 60 minutes after ropivacaine injection;
- No contraindications to getting up and functional tests;
- The appearance of a complication (in particular: hematoma) should be sought during the procedure.

3.2 Depending on the level of precautions (see recommendation 2):
- Level 1: verification of contraindications; the procedure is performed in a suitable room with the possibility of administering oxygen by mask; no pre-anesthetic consultation, no need for an anesthetist; no intravenous line or monitoring; emergency trolley nearby, Intralipid® 20% available.
- Level 2: application of the recommendations published by the SFAR, regardless of the operator.

Rationale

The planning of the procedure takes into account the time required to complete and observe the effects of the nerve block. It is essential to pay attention to the comfort and respect for the patient's bodily privacy. It is desirable to have a truck of equipment dedicated to the block for its achievement. The usual asepsis rules should be applied. Shaving is not recommended, gloves are worn by the operator. During an ultrasound-guided puncture, it is recommended before each procedure that the probes and cables be wiped, cleaned and disinfected. It is recommended to use a sterile single-use protective sheath dedicated and adapted to the ultrasound probe, and sterile single-dose gel. It is recommended that, in the absence of perforation or tearing when removing the protection, the disinfection of the probe between each patient should be at least that corresponding to low-level disinfection. It is recommended that in the event of a sheath failure or probe contamination, the disinfection level should be higher. It is recommended at the end of the

operating program to clean the probe with a detergent, rinse, dry and store it in a clean place. It is recommended to have the various cleaning and disinfection procedures validated by the local hygiene and/or nosocomial diseases committee.

The medical/nursing presence, the patient's monitoring procedures before, during and after a motor nerve block depend directly on the possible complications related to the neurotoxicity and cardiotoxicity of the anesthetic drugs as well as the local risk of hematoma and nerve damage (see Recommendation 2).

In all cases, the procedure must be carried out in a room equipped with oxygen and an aspiration device. The choice of patient monitoring devices, installed before the procedure is performed, depends on the doses of local anesthetic used (see recommendation 2), the procedure (duration, etc.), the comorbidities and the patient's condition. In the event of associated sedation (the need for which is exceptional in this field), an intravenous line and cardiorespiratory monitoring are essential from the outset. Resuscitation equipment for the management of complications must be immediately available and the physician performing the procedure must be trained to use it. Depending on the organization of the department, a room can be dedicated to these procedures. The physician must be able to anticipate and manage the complications of sedation.
The procedure to be followed is adapted to each complication and must be known by all medical and nursing staff involved in the achievement of the motor nerve block and monitoring.
Anesthetic drugs must be used by or under the responsibility of a physician who has been trained in accordance with these recommendations (see Chapter 8).
There should be an easily accessible procedure for dealing with systemic toxicity of local anesthetics (Annex 2). A 250 ml bag of Intralipid® 20% must be available (be careful with the short shelf life).
Monitoring during the surgery is carried out by the physician: slow injection with regular reflux control, maintenance of verbal contact with the patient, monitoring for early signs of neurotoxicity and cardiotoxicity (see 2.2).
Monitoring after the motor nerve block has been completed can be carried out by a nurse, with the physician remaining nearby: monitoring for signs of systemic toxicity, monitoring the lifting of the block (absence of nerve damage), searching for a hematoma. There are no contra-indications to getting up and functional tests.
Duration of monitoring: at least 30 minutes after lidocaine injection, 60 minutes after ropivacaine injection.

Level 2 precautions: The motor nerve block and post-block monitoring will be performed during hospitalization (complete or daytime), with intravenous line, cardiac monitoring, defibrillator.

The action to be taken in the event of complications, not detailed in this article, refers to the literature (22, 26-29).

4. Injection and tracking equipment

Recommendations:

4.1 It is necessary to use a tracking technique in addition to anatomical tracking that cannot be used alone.
4.2 The identification can be done by electrostimulation and/or ultrasound; there is no demonstrated superiority of one over the other but different advantages and disadvantages that sometimes make them complementary. The technique must be chosen according to the operator's experience.
4.3 Recommendations for the tracking mode for nerve blocks can be extrapolated for chemical neurolysis.

Rationale:

Regardless of the tracking technique, prior anatomical, topographical and functional knowledge is essential. The equipment (neurostimulator, ultrasound scanner) must be maintained and be completely checked before each use (21).
Echo-guidance and neurostimulation are the reference tracking techniques. The occurrence of paresthesia in the territory of the corresponding nerve is a sign of the needle/nerf proximity that can signal contact with the nerve trunk and a risk of nerve damage. The onset of severe pain in the sensory territory of the nerve during the procedure requires immediate cessation of the injection. The procedure must be interrupted and the needle slightly removed.

Neurostimulation **(30,31)**
The electrical impulses applied to the tip of the needle trigger the nerve impulse in the nerve sought and consequently, a specific muscle response of that nerve. The use of electrically insulated needles for loco-regional anesthesia, of a size adapted to the depth of the nerve, with a short bevel, which provides tactile sensations useful for the procedure, is recommended. After identifying the puncture marks, the stimulator is switched on before passing the skin. The search is started by gradually increasing the intensity to 2.5 mA (electrical pulse duration 0.1 ms). When a response is obtained, the amount of current is reduced and the needle is mobilized step by step until the best possible response is obtained for the lowest amount of current delivered. Proximity to the nerve is expressed by an effective stimulation of less than 0.5 mA. A suction test is performed before the injection of the local anesthetic solution to check for the absence of blood reflux.

Ultrasound **(32.33)**
Ultrasound-guidance makes it possible to visualize the nerve structure, the needle approaching it, the diffusion of local anesthetic and thus improve the precision of the block, while reducing the volumes injected and failures. Two of the main current limitations remain depth resolution and contour accuracy. Understanding the physical basis of ultrasound and ultrasound settings is recommended for performing peripheral nerve blocks under ultrasound with confidence and safety. It is essential to have anatomical and sonographic-anatomical knowledge to identify the structures concerned. Prior training is recommended for the acquisition of sonographic-anatomy and the visualization of the needle to its target (manikin model and/or anatomical parts). Understanding the techniques of guiding the needle "in the plane" and "out of the plane" is a prerequisite for the safety and success of the gesture. Additional means may be recommended for the realization of the block: neurostimulation and/or displacement of tissues with the movements

of the needle. It is recommended to use the highest possible frequency to give priority to spatial resolution and improve image accuracy. It is recommended to carry out, before the procedure, a wide and dynamic visualization of the anatomical elements by precisely searching for the target and adjacent structures using the functionalities available on the ultrasound scanner. Following this procedure makes it possible to plan the trajectory of the needle, determine the plane of visualization of the nerve (in small and/or large axis) and the technique of progression of the needle. In order to limit the risk of an intraneural injection, it is probably recommended to approach the nerve tangentially and to check before injection, by small mobilizations of the needle, that its end is not attached to the nerve. It is recommended to discontinue the injection of the anesthetic solution in the absence of real-time visualization of the diffusion of the local anesthetic and/or in the event of pain, paresthesia, resistance to injection, or nerve swelling that indicates an intraneural injection.

The SFAR 2016 recommendations: “recommend the use of ultrasound guidance for the achievement of a loco-regional anesthesia etc.” with a grade 1+ strong agreement (26).
The criteria of superiority (efficacy and safety) regarding ultrasound versus electrostimulation techniques for blocks proposed by the literature in the field of anesthesia apply to specific indications for this practice (34-42).
The literature in anesthesia is difficult to transpose for PRM practice because the objectives are different (motor vs sensory block), they are not the same nerve locations (distal and selective approach as much as possible), the constraints are different (no argument of speed of realization, there is no need for a complete sensory block), the volumes and products injected are different, vascular complications are less to fear (low volume vascular trunks in distal) and there is no use of associated molecules.

As the literature in PRM is very poor and does not allow for an opinion, only guidelines based on the advice of experts can be proposed.
When these criteria are transposed to PRM practice (execution modalities, efficacy and safety), it does not appear that ultrasound injection is superior to electrostimulated injection. In addition, the experts note that for ultra-selective blocks, nervous detection can be very difficult under ultrasound. The criterion that seems to make one choose one specific technique rather than another seems to be more related to the training and experience of the person performing the injection.

Anatomical identification alone does not make it possible to perform this procedure effectively and therefore exposes the patient to unequal risks of the above-mentioned technique.

Type of needles used for electrostimulation
Reminder of SFAR recommendations 2003 (31):
- Only isolated needles are recommended.
- Bevel shape: the use of a short bevel (20-30°) is recommended (A), as it causes less nerve damage than a long bevel needle (12-15°) (C). “Pencil-tip” bevel needles have the triple disadvantage of poor tissue penetration, a different stimulation point at the injection site and poor tolerance by the patient.

5. Preparing the Patient and possible analgesia

Recommendations

5.1 The patient should be informed regarding the procedure and the possible pain.
5.2 Patient participation in the choice of premedication should be effective as far as possible.
5.3 Pre-medication with anxiolytics may be helpful. In this case, the monitoring of toxicity warning symptoms will be strengthened.
5.4 All non-drug techniques (conversational hypnosis, music therapy, "Energy Resonance by Dermal Stimulation" etc.) can be useful complementary techniques.
5.5 It is possible to offer analgesic prevention before the achievement of a motor nerve block. Several options are possible and recommended:

- Application of a local skin anesthetic agent (EMLA type).
- Equimolar gas mixture of oxygen and nitrous oxide (EMONO).

Rationale

Motor nerve blocks are potentially painful procedures. The target population has more frequent chronic, nociceptive or neuropathic pain secondary to central nervous system involvement (43). Although not all mechanisms are elucidated, spasticity can also potentially cause pain. Thus, patients to whom the motor nerve blocks are addressed may therefore have a particular painful terrain.
Some patients have cognitive impairment. The pain induced by the gesture can cause withdrawal reactions in these patients, sudden movements that are difficult to control and make it less easy to perform the gesture.
Anticipating the pain induced by performing a motor nerve block is therefore essential. There is no specific literature on the prevention of pain induced by a PRM motor block. On the other hand, the literature on the prevention of pain caused by these procedures is abundant in pediatrics, urology and oncology (44). Our recommendations are based on the latest systematic reviews and recommendations in the prevention of care-induced pain (45-49).

Main therapeutics studied

Lidocaine and prilocaine cream
EMLA cream can be used for all punctures: venous, arterial, lumbar. This cream, made up of two local anesthetics (lidocaine 2.5% and prilocaine 2.5%), acts by diffusion through healthy skin to a depth of 5mm in 1h30.

The equimolar gas mixture of oxygen and nitrous oxide
The equimolar gas mixture of oxygen and nitrous oxide (EMONO) is a good way to control induced pain (45-49). In addition to analgesia during needle puncture, this technique has the potential to control pain induced by electrostimulation in patients with central neurological impairment. There is no literature on the subject of motor nerve blocks.

Pre-medication with anxiolytics or opioids.

Pre-medication with anxiolytics may be helpful. In this case, the monitoring of toxicity warning symptoms will be strengthened. It should be used with caution in patients at risk of respiratory decompensation. Above all, it has the potential disadvantage of disrupting functional tests that make it possible to judge the interest and effectiveness of the block, depending on the patient's sensitivity to therapy. In case of use, products should be selected at ½ short disposal half-life.
The use of opioids is not recommended.

Pediatric procedures: Non-pharmacological methods have proven their effectiveness in preventing gesture-induced pain (positioning, suction, massage) and are therefore recommended. The use of glucose/sugar 2 minutes before the procedure is also effective. Practitioners should be cautious about the use of pharmacological treatments, including opioids that may induce respiratory depression.

All non-drug techniques (conversational hypnosis, music therapy, "Energy Resonance by Dermal Stimulation" etc.) can be useful complementary techniques.

6. Efficacy Control

Recommendations

6.1 The motor nerve block must be designed by first determining assumptions about the factors contributing to the discomfort, and must therefore answer specific questions.
6.2 It is important to take into account the time for the motor nerve block to be effective (depending on the drug used) and to verify, when possible, the efficacy of the nervous blocking (abolition of spasticity, presence of sensory disorders if mixed nerve etc.).
6.3 There are several aspects to the evaluation:
- The analytical evaluation to analyze the mechanisms of the neuro-motor disorders involved in the difficulties observed.
- The situation evaluation to measure the effect of the motor nerve block in the situation(s) at the cause of the discomfort reported by the patient, their entourage or the therapist.
- Assessment of the patient's or caregiver's subjective feelings.

6.4 The evaluation should preferably be based on validated tools adapted to the patients' problems.
6.5 Evaluation data should be recorded in the medical file, and conclusions should be formulated, including, as far as possible, therapeutic proposals.

Rationale

Pre- and post-block evaluation depends on the objectives (see recommendation 1). At the end of the block, the evaluation should determine the different factors involved in the discomfort presented and allow a therapeutic proposal to be formulated.

Evaluation conditions
- To have environmental and material conditions allowing a good analytical evaluation but also in situation (according to the various problems envisaged). This includes, but is not limited to,

sufficient walking space, the availability of technical aids (for walking or getting up), nearby stairs, an accessible plan and test objects for gripping analysis.
- Allow sufficient time for the evaluation, depending on the program being considered (single or sequential blocks).
- The complex nature of the assessment may justify a multidisciplinary assessment in hospital (full or day hospitalization).

Criteria for assessing the efficacy of the motor nerve block
The following criteria are used to judge the effectiveness (in the physiological sense) of the motor nerve block:
- Disappearance of a clonus when it is present before the block and/or disappearance/displacement of the first spastic jump when the muscle(s) targeted by the motor block are stretched.
- When the block is performed on a mixed nerve trunk: perception by the patient of a sensation of heat, paresthesia or a lack of sensitivity in the territory of the nerve targeted by the motor block.

It is important to take into account the duration of action of the local anesthetic used (see Chapter 2).
If the efficacy criteria of the motor nerve block are not met, it should be renewed (if the cumulative dose of local anesthetic is not exceeded).

Organisation of the evaluation of the effects of the motor nerve block
The evaluation strategy is based on the definition of the discomfort(s) encountered by the patient. The block will help to determine the factors that contribute to this discomfort (see recommendation 1). The assessment also takes into account other disorders that impact motor behavior (sensory affective disorders, coordination disorders, movement preparation disorders, cognitive disorders, etc.).
The evaluation compares the condition before and after the block. It must therefore be carried out under the same conditions and with the same tools.
It should be kept in mind that the evaluation of a functional effect (on walking or grasping) may be incomplete in the time of effect of the block, taking into account the time required for the patient to adapt to the change in the motor pattern.
The assessment is carried out by the examiner and the patient or their family and friends.

<u>Evaluation by the examiner:</u>
The objective of the analytical evaluation is to analyse the mechanisms of neuro-motor disorders involved in the difficulties observed: differentiating hypertonia and muscle retraction, evaluation of motor skills on agonists and antagonists. It can involve: passive goniometry; spasticity assessment (it is recommended to use the Tardieu scale rather than the Ashworth scale) and paresis assessment (active goniometry and muscle testing, even if there are limitations in case of central nervous system disorder, being careful to differentiate between voluntary and synkinetic motricity). It is not recommended to use EMG evaluation (Hmax/Mmax ratio) or instrumental goniometry in clinical practice.

The evaluation of the situation makes it possible to measure the effect of the motor block in the situation(s) causing the discomfort reported by the patient, their entourage or the therapist. The assessment is therefore adapted to the objective and the patient:

Analysis of the walking or gripping pattern, transfers, standing position: in addition to clinical analysis, it is recommended to use quantitative instrumental evaluations that provide more detailed analysis and facilitate pre/post comparisons. It is therefore recommended to use a video recording (using two perpendicular shooting axes) and photo recording. The use of systems to measure joint kinematics (3D video, actimetric sensors, etc.) is not systematically required.

Evaluation of the contribution of the block in passive functions (positioning in bed or in the chair, simulation of daily life activities, sampling...).

Evaluation by the patient or his entourage on the discomfort (pain etc.), assessment of overall satisfaction (EVA, numerical scale), and assessment of change centered on one or more objectives by the Global Assessment Scale, assessment centered on objectives by the Goal Attainment Scale (GAS) or EVA.

The evaluation data must be included in the medical file as well as in the summary letter.

7. Patient information (form and content)

Recommendations

7.1 Patient information is an obligation before the performing a diagnostic motor nerve block. It must be done orally, but it is recommended to use a written support. The collection of oral consent is necessary and sufficient.
7.2 If the patient is a minor, the consent of at least one of his legal representatives is required. If the patient is a protected adult, the consent of the legal representative is not routinely required. The principle of personal autonomy applies unless specifically notified by the guardianship judge. However, the legal representative must always receive the information to enable him/her to assist the protected person in their reflection.
7.3 Traces of supplying information to the patient (and any difficulties encountered in obtaining it) and the collection of consent must be recorded in the medical records.
7.4 The objectives of the block must be defined beforehand, with the patient.

Rationale

Information is a fundamental right of the patient to exercise their free will over the proposed gesture or treatment, to allow them to accept or refuse it (50,51). This fair, clear and appropriate information is a prerequisite for the free and informed consent that the physician must obtain before any intervention for a medical purpose (52,53). This is all the more true since the motor nerve block is a functional (and not vital) support and is never carried out urgently.

How to inform the patient or their representative and obtain their consent?

On the form: oral and/or written support of information and consent:
The HAS recommendations on the modalities of information given to the patient (54) recall that "information is necessarily oral", and that "in addition to this information, when written

documents exist, it is recommended to give them to the person to allow them to refer to them and/or to discuss them with any person of their choice. These documents are also intended to raise questions that the health professional answers". The information document is intended exclusively to provide the person with written information. This document does not have to be signed by the patient and does not contain any form inviting them to sign it. Under no circumstances should the provision of such a standard document replace the personalized oral exchange. The practitioner must ensure that the patient completely understands the information.

Oral consent is sufficient for the practice of diagnostic motor blocks. The signature of a written consent does not release the physician of any liability and does not have absolute legal value except when required by law.

Reflection period:
It does not seem obligatory give the patient a reflection period before carrying out a motor nerve block for diagnostic purposes. However, it is recommended not to perform the procedure on the same day as the first consultation with the patient if the practitioner considers that the conditions necessary for a good evaluation are not met (time constraints, for example) or if the procedure requires special preparation (anticoagulant treatment relay, management of the patient's transportation who could not recover their vehicle, etc.).

Concerning the information and consent of protected minors and adults, the legislative texts for France are quoted as a reference (56-59).

What evidence of information? Proof of the information must be included in the patient's medical record and/or in the letter addressed to the patient (recommended to be dictated in the patient's presence). The traces must cover both the information provided, any difficulties observed in its provision and the obtaining of consent.

What does it contain?
The information can be structured around the following points: Why make a motor nerve block? What is the mechanism of action of a motor nerve block? Is there any particular preparation before a motor nerve block? How does a motor nerve block work? What are the potential complications?

A patient information document on the design of diagnostic motor nerve blocks has been developed following the recommendations of the HAS (54,59) and drawing on existing documents (electronic annex available on the Annals of PRM website).

8. Training of the practicing physician

Recommendations

8.1 The practice of motor nerve blocks requires training in their particular indications, their potential risks and knowledge of these recommendations.
8.2 Identification techniques require teaching with a learning curve and a prerequisite of anatomical knowledge.
8.3 This training must be provided through an initial and ongoing PRM training program.

Rationale:

The objectives of the training are: to know how to propose a motor nerve block and evaluate its results; to know the side-effects of locoregional anesthesia; to know the anatomy of the limbs; to know how to identify nerve trunks and their branches by electrostimulation and ultrasonography; to know the present recommendations concerning the practice of motor nerve blocks.
The basics for the practice of motor nerve blocks are taught to all PRM residents. They correspond to the competency framework of the French college of university teachers of Physical and Rehabilitation Medicine (COFEMER 2010) (60).
Means used:
- Courses for residents in PRM including modules on physiological basis and musculoskeletal and motor evaluation, the module on motor disorders in central nervous system disorders, and the optional module on spasticity.
- Neurologically oriented PRM internships with practice in motor nerve blocks and Botulinum toxin injections.
- For a PRM physician who has not completed this initial training: practical training in an experienced department.
- The training is also done in practice: without imposing a minimum number of blocks, regular practice is highly recommended.

Conflict of Interest:
The authors confirm that they don't have any conflict of interest according to these recommendations.

References:

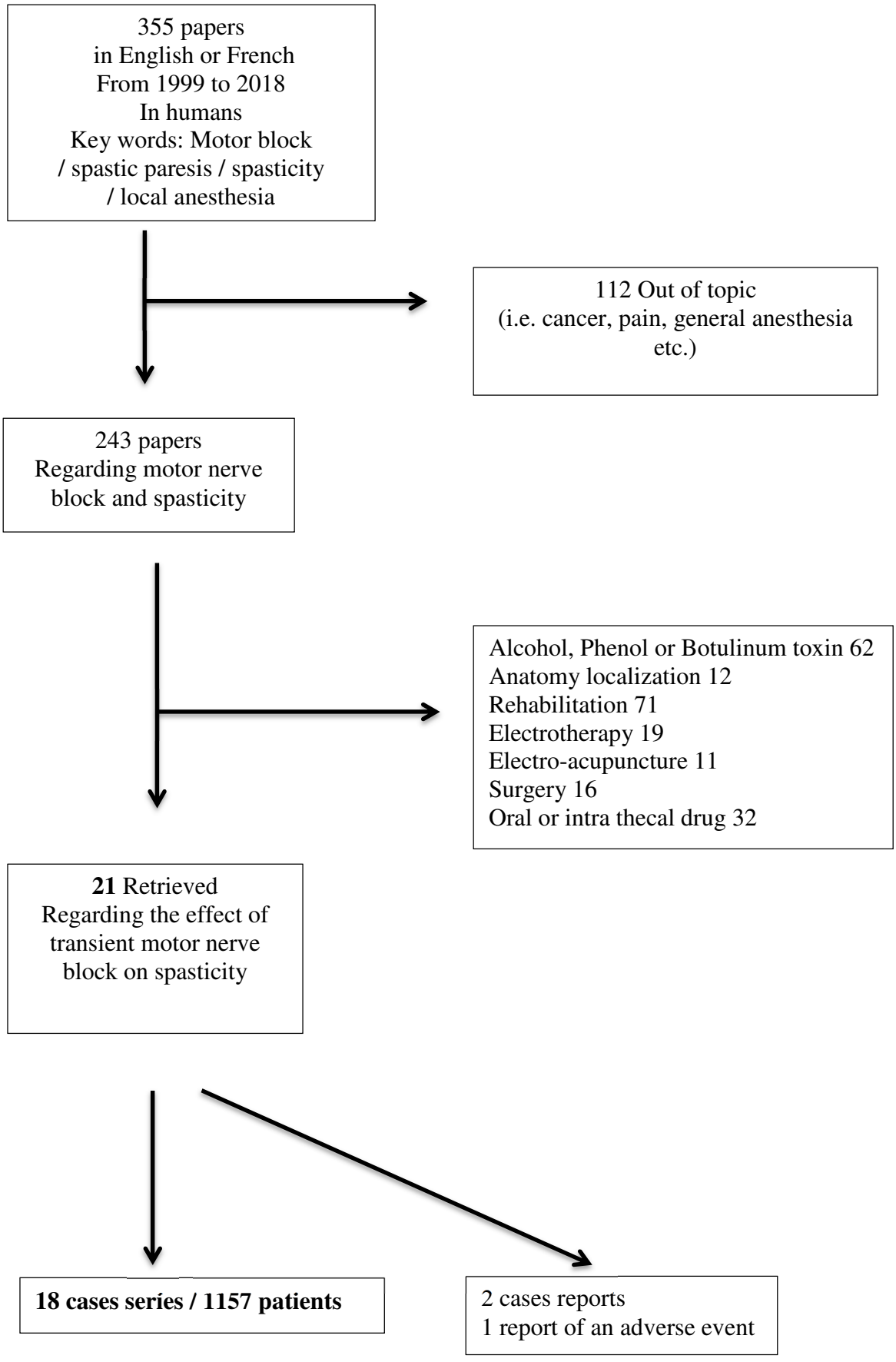
1. Filipetti P, Decq P. Interest of anesthetic blocks for assessment of the spastic patient. A series of 815 motor blocks. Neurochirurgie. 2003;49:226-38.
2. Bleyenheuft C, Detrembleur C, Deltombe T, Fomekong E, Lejeune TM. Quantitative assessment of anesthetic nerve block and neurotomy in spastic equinus foot: a review of two cases. J Rehabil Med. 2008;40:879-81.
3. Arendzen JH, van Duijn H, Beckmann MK, Harlaar J, Vogelaar TW, Prevo AJ. Diagnostic blocks of the tibial nerve in spastic hemiparesis. Effects on clinical, electrophysiological and gait parameters. Scand J Rehabil Med. 1992;24:75-81.
4. C. Hentzen, V. Quintaine, M. Jousse, A. Yelnik. Blocs moteurs des nerfs périphériques en MPR. Actualités en MPR 2017,4: 29-33
5. Sung DH, Bang HJ. Motor branch block of the rectus femoris: its effectiveness in stiff-legged gait in spastic paresis. Arch Phys Med Rehabil. 2000;81:910-5.
6. Albert TA, Yelnik A, Bonan I, Lebreton F, Bussel B. Effectiveness of femoral nerve selective block in patients with spasticity: preliminary results. Arch Phys Med Rehabil 2002;83:692-6.
7. Deltombe T, De Wispelaere J-F, Gustin T, Jamart J, Hanson P. Selective blocks of the motor nerve branches to the soleus and tibialis posterior muscles in the management of the spastic equinovarus foot. Arch Phys Med Rehabil. 2004;85:54-8.

8. Buffenoir K, Decq P, Lefaucheur J-P. Interest of peripheral anesthetic blocks as a diagnosis and prognosis tool in patients with spastic equinus foot: a clinical and electrophysiological study of the effects of block of nerve branches to the triceps surae muscle. Clin Neurophysiol. 2005;116:1596-600.
9. Chantraine F, Detrembleur C, Lejeune TM. Effect of the rectus femoris motor branch block on post-stroke stiff-legged gait. Acta Neurol Belg 2005;105:171-7.
10. Deltombe T, Jamart J, Hanson P, Gustin T. Soleus H reflex and motor unit number estimation after tibial nerve block and neurotomy in patients with spastic equinus foot. Neurophysiol Clin Clin Neurophysiol. 2008;38:227-33.
11. Lee J, Lee YS. Percutaneous chemical nerve block with ultrasound-guided intraneural injection. Eur Radiol. 2008;18:1506-12.
12. Robertson JVG, Pradon D, Bensmail D, Fermanian C, Bussel B, Roche N. Relevance of botulinum toxin injection and nerve block of rectus femoris to kinematic and functional parameters of stiff knee gait in hemiplegic adults. Gait Posture 2009;29:108-12.
13. Gross R, Leboeuf F, Rémy-Néris O, Perrouin-Verbe B. Unstable gait due to spasticity of the rectus femoris: gait analysis and motor nerve block. Ann Phys Rehabil Med. 2012;55:609-22.
14. Bhardwaj P, Sabapathy SR. Treatment of upper limb extensor hypertonia: case report. J Hand Surg. 2013;38:1983-6.
15. Gross R, Delporte L, Arsenault L, Revol P, Lefevre M, Clevenot D, et al. Does the rectus femoris nerve block improve knee recurvatum in adult stroke patients? A kinematic and electromyographic study. Gait Posture 2014;39:761-6.
16. Ghroubi S, Elleuch W, Mahersi S, Elleuch M, Elleuch MH. L'apport des blocs anesthésiques dans l'évaluation du patient spastique : à propos de 146 blocs moteurs. J Réadapt Médicale 2014;34:191-7.
17. Genet F, Schnitzler A, Droz-Bartholet F, Salga M, Tatu L, Debaud C, et al. Successive motor nerve blocks to identify the muscles causing a spasticity pattern: example of the arm flexion pattern. J Anat. 2017;230:106-16.
18. Khalil N, Chauvière C, Le Chapelain L, Guesdon H, Speyer E, Bouaziz H, et al. Plantar pressure displacement after anesthetic motor block and tibial nerve neurotomy in spastic equinovarus foot. J Rehabil Res Dev. 2016;53:219-28.
19. Dehem S, Gilliaux M, Lejeune T, Detrembleur C, Galinski D, Sapin J, et al. Assessment of upper limb spasticity in stroke patients using the robotic device REAplan. J Rehabil Med. 2017;7:565-571.
20. Viel E. Neurophysiological approach in the peripheral anesthetic blocks as a diagnosis and prognosis tool for spasticity. Clin Neurophysiol. 2005;116:1491-2
21. Société française d'anesthésie et de réanimation, Samu de France; Société francophone de médecine d'urgence. Use of local and locoregional anesthesia by physicians not specialized in anesthesia-reanimation, within the frame of emergencies. Ann Fr Anesth Reanim. 2004;23:167-76. http://sfar.org/wp-content/uploads/2016/01/2_AFAR_Pratique-des-anesthesies-locales-et-locoregionales-par-des-medecins-non-specialises-en-anesthesie-reanimation-dans-le-cadre-des-urgences.pdf
22. Société française d'anesthésie et de réanimation SFAR Intoxication aux anesthésiques locaux 2016.
http://sfar.org/wp-content/uploads/2016/09/Intoxication-aux-anesthesiques-locaux.pdf
23. Sambrook PJ. Severe adverse reactions to dental local anesthetics: systemic reactions. Aust Dent J. 2011;56:148-53; quiz 234. doi: 10.1111/j.1834-7819.2011.01316.x.

24. Deltombe T, Nisolle JF, De Cloedt P, Hanson P, Gustin T. Tibial nerve block with anesthetics resulting in achilles tendon avulsion. Am J Phys Med Rehabil 2004 ; 83 : 331-4
25. Narouze S, Benzon HT, Provenzano D, Buvanendran A, De Andres J, Deer T, et al. Interventional Spine and Pain Procedures in Patients on Antiplatelet and Anticoagulant Medications (Second Edition): Guidelines From the American Society of Regional Anesthesia and Pain Medicine, the European Society of Regional Anesthesia and Pain Therapy, the American Academy of Pain Medicine, the International Neuromodulation Society, the North American Neuromodulation Society, and the World Institute of Pain. Reg Anesth Pain Med. 2018 ;43 :225-262 doi: 10.1097/AAP.0000000000000700
26. Carles M, Beloeil H, Bloc S, et al. SFAR Société Française d'Anesthésie et de Réanimation. Recommandations formalisées d'experts. Anesthésie Loco-Régionale périnerveuse (ALR-PN) Expert panel guidelines on perineural anesthesia. 2016. http://sfar.org/wp-content/uploads/2016/12/2_RFE_ALR_2016.pdf
27. Haute Autorité de santé Prise en charge des surdosages en antivitamines K, des situations à risque hémorragique et des accidents hémorragiques chez les patients traités par antivitamines K en ville et en milieu hospitalier [Internet]. Avril 2008. https://www.has-sante.fr/portail/upload/docs/application/pdf/2008-09/surdosage_en_avk_situations_a_risque_et_accidents_hemorragiques_-_recommandations_v2.pdf
28. Neal JM, Barrington MJ, Fettiplace MR, Gitman M, Memtsoudis SG, Mörwald EE, et al. The Third American Society of Regional Anesthesia and Pain Medicine Practice Advisory on Local Anesthetic Systemic Toxicity: Executive Summary 2017. Reg Anesth Pain Med. 2018;43:113-123. doi: 10.1097/AAP.0000000000000720
29. Neal JM, Woodward CM, Harrison TK. The American Society of Regional Anesthesia and Pain Medicine Checklist for Managing Local Anesthetic Systemic Toxicity: 2017 Version. Reg Anesth Pain Med. 2018;43 :150-153. doi: 10.1097/AAP.0000000000000726.
30. Feugeas J-L, Choquet O. Comprendre et optimiser la neurostimulation. Congrès national d'anesthésie et de réanimation 2007. Les Essentiels © 2007 Elsevier Masson SAS.
31. Société française d'anesthésie et de réanimation. Recommandations pour la pratique clinique. Les blocs périphériques des membres chez l'adulte. Peripheral nerve block of limbs in the adult. Ann Fr Anesth Reanim. 2003;22:567-81. http://sfar.org/wp-content/uploads/2015/10/2_AFAR_Les-blocs-peripheriques-des-membres-chez-l-adulte.pdf
32. Bouaziz H, Aubrun F, Belbachir AA, Cuvillon P, Eisenberg E, Jochum D, et al. Échographie en anesthésie locorégionale. Ann Fr Anesth Reanim. 2011;30:e33-5. doi: 10.1016/j.annfar.2011.06.008.
33. Yoshida T, Nakamoto T, Kamibayashi T. Ultrasound-guided Obturator Nerve Block: A focused review on anatomy and updated techniques. BioMed Research International 2017, ;2017:7023750. doi: 10.1155/2017/7023750
34. Abrahams MS, Aziz MF, Fu RF, Horn JL. Ultrasound guidance compared with electrical neurostimulation for peripheral nerve block: a systematic review and meta-analysis of randomized controlled trials. Br. J. Anaesth. 2009;102,408–417.
35. Danelli, G. Fanelli A, Ghisi D, Moschini E, Rossi M, Ortu A, et al. Ultrasound vs nerve stimulation multiple injection technique for posterior popliteal sciatic nerve block. Anaesthesia 2009;64,638–642.
36. Lam DKM, Corry GN, Tsui BC. H. Evidence for the Use of Ultrasound Imaging in Pediatric Regional Anesthesia: A Systematic Review. Reg. Anesth. Pain Med. 2016;41:229–241.

37. Cao X, Zhao X, Xu J, Liu Z, Li Q. Ultrasound-guided technology versus neurostimulation for sciatic nerver block: a meta-analysis. Int. J. Clin. Exp. Med. 2015;8:273–280.
38. Lewis SR, Price A, Walker KJ, McGrattan K, Smith AF. Ultrasound guidance for upper and lower limb blocks. Cochrane Database Syst. Rev. CD006459 (2015). doi:10.1002/14651858.CD006459.pub3
39. Redborg KE, Sites BD, Chinn CD, Gallagher JD, Ball PA, Antonakakis JG et al. Ultrasound improves the success rate of a sural nerve block at the ankle. Reg. Anesth. Pain Med. 2009;34:24–28.
40. Chin KJ, Wong NWY, Macfarlane A J R, Chan VWS. Ultrasound-guided versus anatomic landmark-guided ankle blocks: a 6-year retrospective review. Reg. Anesth. Pain Med. 2011;36,611–618.
41. van Geffen GJ, van den Broek E, Braak GJ, Giele JL, Gielen MJ, Scheffer GJ. A prospective randomised controlled trial of ultrasound guided versus nerve stimulation guided distal sciatic nerve block at the popliteal fossa. Anaesth. Intensive Care 2009;37,32–37.
42. Schnabel, A., Meyer-Frießem, C. H., Zahn, P. K., Pogatzki-Zahn, E. M. Ultrasound compared with nerve stimulation guidance for peripheral nerve catheter placement: a meta-analysis of randomized controlled trials. Br. J. Anaesth. 2013;111:564–572.
43. Paolucci S, Martinuzzi A, Scivoletto G, Smania N, Solaro C, Aprile I, et al. Assessing and treating pain associated with stroke, multiple sclerosis, cerebral palsy, spinal cord injury and spasticity. Evidence and recommendations from the Italian Consensus Conference on Pain in Neurorehabilitation. Eur J Phys Rehabil Med. 2016;52:827-40.
44. Krakowski I, Theobald S, Fabre N, Delorme T, Binhas M, Collin E, et al. Recommandations pour la pratique clinique 2005 : Standards, Options et Recommandations pour la prise en charge des douleurs provoquées lors des ponctions lombaires, osseuses et sanguines chez l'adulte atteint de cancer (rapport intégral) . Bull Cancer 2005;92:465-88.
45. Takkar D, Rao A, Shenoy R, Rao A, Saranya BS. Evaluation of nitrous oxide inhalation sedation during inferior alveolar block administration in children aged 7-10 years: a randomized control trial. J Indian Soc Pedod Prev Dent. 2015;33:239-44.
46. Jacobs S, Haas DA, Meechan JG, May S. Injection pain: comparison of three mandibular block techniques and modulation by nitrous oxide:oxygen. J Am Dent Assoc 1939. 2003;134:869-76.
47. Moisset X, Sia MA, Pereira B, Taithe F, Dumont E, Bernard L, et al. Fixed 50:50 mixture of nitrous oxide and oxygen to reduce lumbar-puncture-induced pain: a randomized controlled trial. Eur J Neurol. 2017;24:46-52.
48. Meskine N, Vullierme M-P, Zappa M, d'Assignies G, Sibert A, Vilgrain V. Evaluation of analgesic effect of equimolar mixture of oxygen and nitrous oxide inhalation during percutaneous biopsy of focal liver lesions: a double-blind randomized study. Acad Radiol. 2011;18:816-21.
49. Young A, Ismail M, Papatsoris AG, Barua JM, Calleary JG, Masood J. Entonox® inhalation to reduce pain in common diagnostic and therapeutic outpatient urological procedures: a review of the evidence. Ann R Coll Surg Engl. 2012;94:8-11.
50. Article 35 du code de déontologie médicale portant sur l'information au patient |Legifrance [Internet][cité 2 juin 2018] https://www.legifrance.gouv.fr/affichCodeArticle.do;jsessionid=8CA764DE7C2E7F50B20119540208BD99.tplgfr39s_3?cidTexte=LEGITEXT000006072634&idArticle=LEGIARTI000006680538&dateTexte=20180612&categorieLien=id#LEGIARTI000006680538
51. Article R4127-35 du code de la santé publique portant sur l'information au patient |Legifrance [Internet][cité 2 juin 2018]

https://www.legifrance.gouv.fr/affichCodeArticle.do;jsessionid=8CA764DE7C2E7F50B20119540208BD99.tplgfr39s_3?idArticle=LEGIARTI000025843586&cidTexte=LEGITEXT000006072665&dateTexte=20180612
52. Article 36 du code de déontologie médicale portant sur le consentement du patient |Legifrance [Internet][cité 2 juin 2018] https://www.legifrance.gouv.fr/affichCodeArticle.do;jsessionid=8CA764DE7C2E7F50B20119540208BD99.tplgfr39s_3?idArticle=LEGIARTI000006680539&cidTexte=LEGITEXT000006072634&dateTexte=20040807&categorieLien=id&oldAction=&nbResultRech=
53. Article R4127-36 du code de la santé publique portant sur le consentement du patient |Legifrance [Internet][cité 2 juin 2018] https://www.legifrance.gouv.fr/affichCodeArticle.do;jsessionid=8CA764DE7C2E7F50B20119540208BD99.tplgfr39s_3?idArticle=LEGIARTI000032973595&cidTexte=LEGITEXT000006072665&categorieLien=id&dateTexte=
54. Haute Autorité de Santé. Recommandation de bonnes pratiques. Délivrance de l'information à la personne sur son état de santé. Mai 2012. [Internet] https://www.has-sante.fr/portail/upload/docs/application/pdf/2012-06/recommandations_-_delivrance_de_linformation_a_la_personne_sur_son_etat_de_sante.pdf
55. Article 42 du code de déontologie médicale portant sur les soins à donner à un mineur ou un majeur protégé |Legifrance [Internet][cité 2 juin 2018] https://www.legifrance.gouv.fr/affichCodeArticle.do;jsessionid=8CA764DE7C2E7F50B20119540208BD99.tplgfr39s_3?cidTexte=LEGITEXT000006072634&idArticle=LEGIARTI000006680548&dateTexte=20180612&categorieLien=id#LEGIARTI000006680548
56. Article R4127-42 du code de la santé publique portant sur les soins à donner à un mineur ou un majeur protégé |Legifrance [Internet][cité 2 juin 2018] https://www.legifrance.gouv.fr/affichCodeArticle.do?cidTexte=LEGITEXT000006072665&idArticle=LEGIARTI000006912905&dateTexte=&categorieLien=cid
57. Article 372-2 du code civil portant sur l'autorité parentale |Legifrance [Internet][cité 2 juin 2018] https://www.legifrance.gouv.fr/affichCodeArticle.do?idArticle=LEGIARTI000006426536&cidTexte=LEGITEXT000006070721
58. Loi n° 2007-308 du 5 mars 2007 portant réforme de la protection juridique des majeurs |Legifrance [Internet] [cité 2 juin 2018] juridiquehttps://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000000430707&dateTexte=20180612
59. Haute Autorité de Santé. Guide Méthodologique. Élaboration d'un document écrit d'information à l'intention des patients et des usagers du système de santé. Juin 2008 [Internet] https://www.has-sante.fr/portail/upload/docs/application/pdf/2009-10/elaboration_document_dinformation_des_patients_-_guide_methodologique.pdf
60. COFEMER Compétences détaillées en MPR en fin de 3ème CYCLE (2010) [Internet] http://www.cofemer.fr/UserFiles/File/2010_comp%C3%A9tences_3%C3%A8meCycleMPR_D%C3%A9taill%C3%A9es_V6_29-10(3).pdf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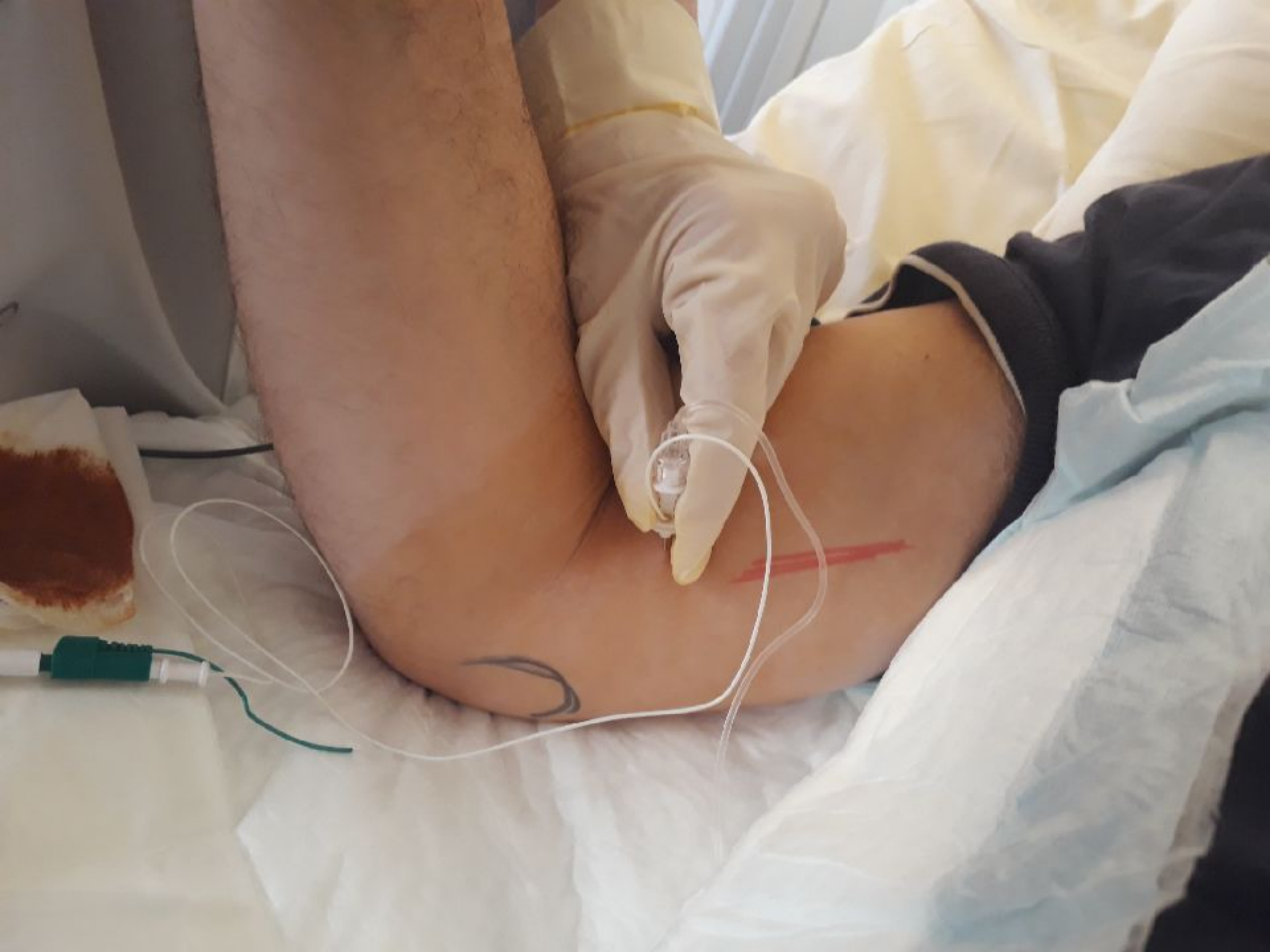
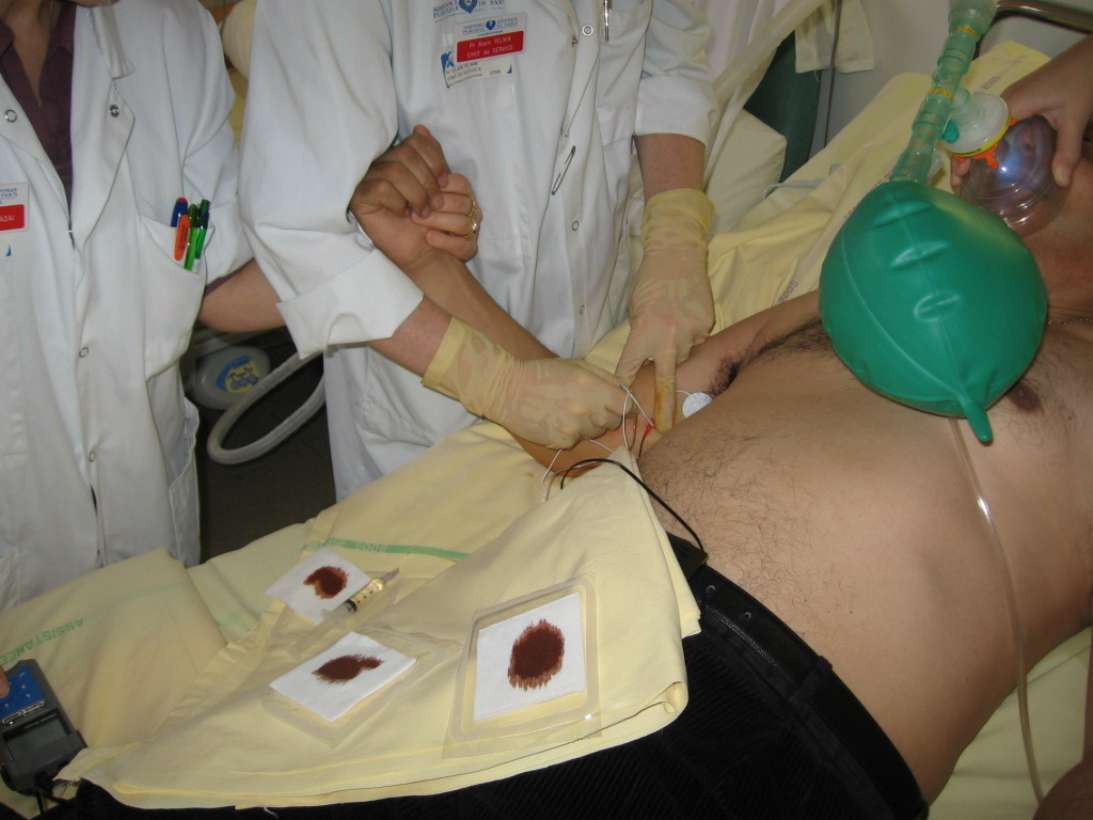
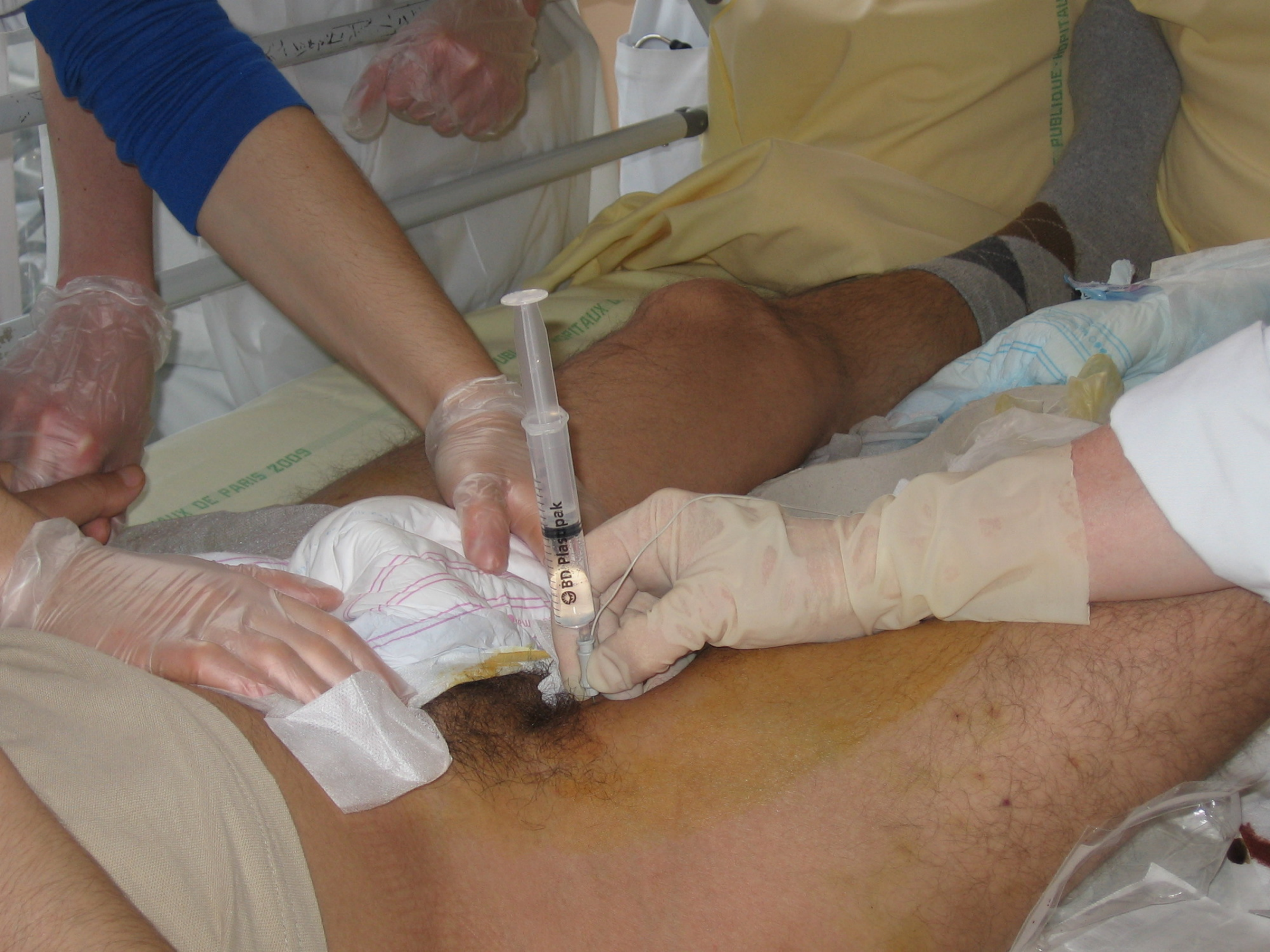
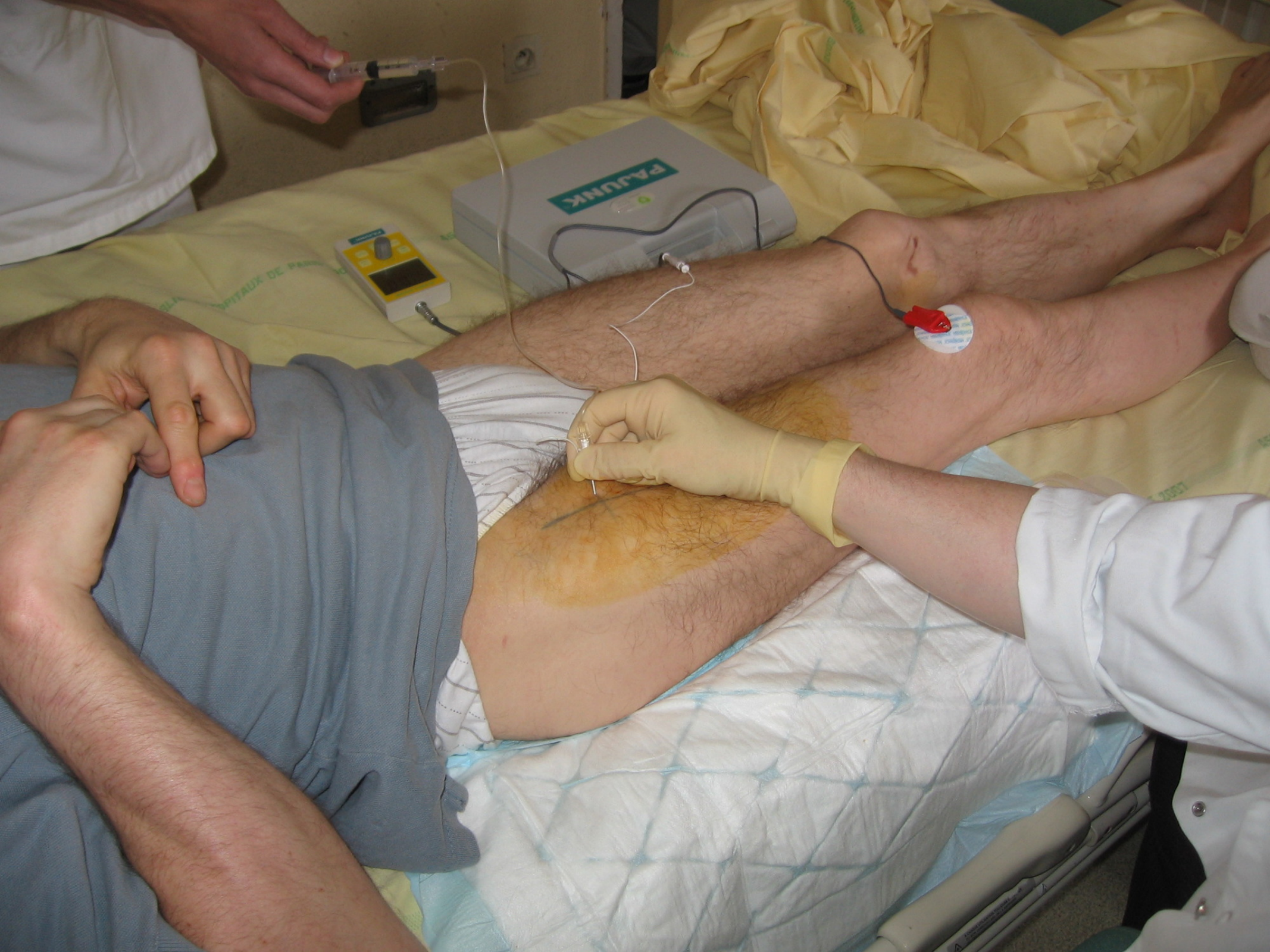
From 1999 to 2018
In humans
Key words: Motor block / spastic paresis / spasticity / local anesthesia
112 Out of topic
(i.e. cancer, pain, general anesthesia etc.)
243 papers
Regarding motor nerve block and spasticity
Alcohol, Phenol or Botulinum toxin 62
Anatomy localization 12
Rehabilitation 71
Electrotherapy 19
Electro-acupuncture 11
Surgery 16
Oral or intra thecal drug 32
21 Retrieved
Regarding the effect of transient motor nerve block on spasticity
18 cases series / 1157 patients
2 cases reports
1 report of an adverse event






BD Plastipak


PAJUNK

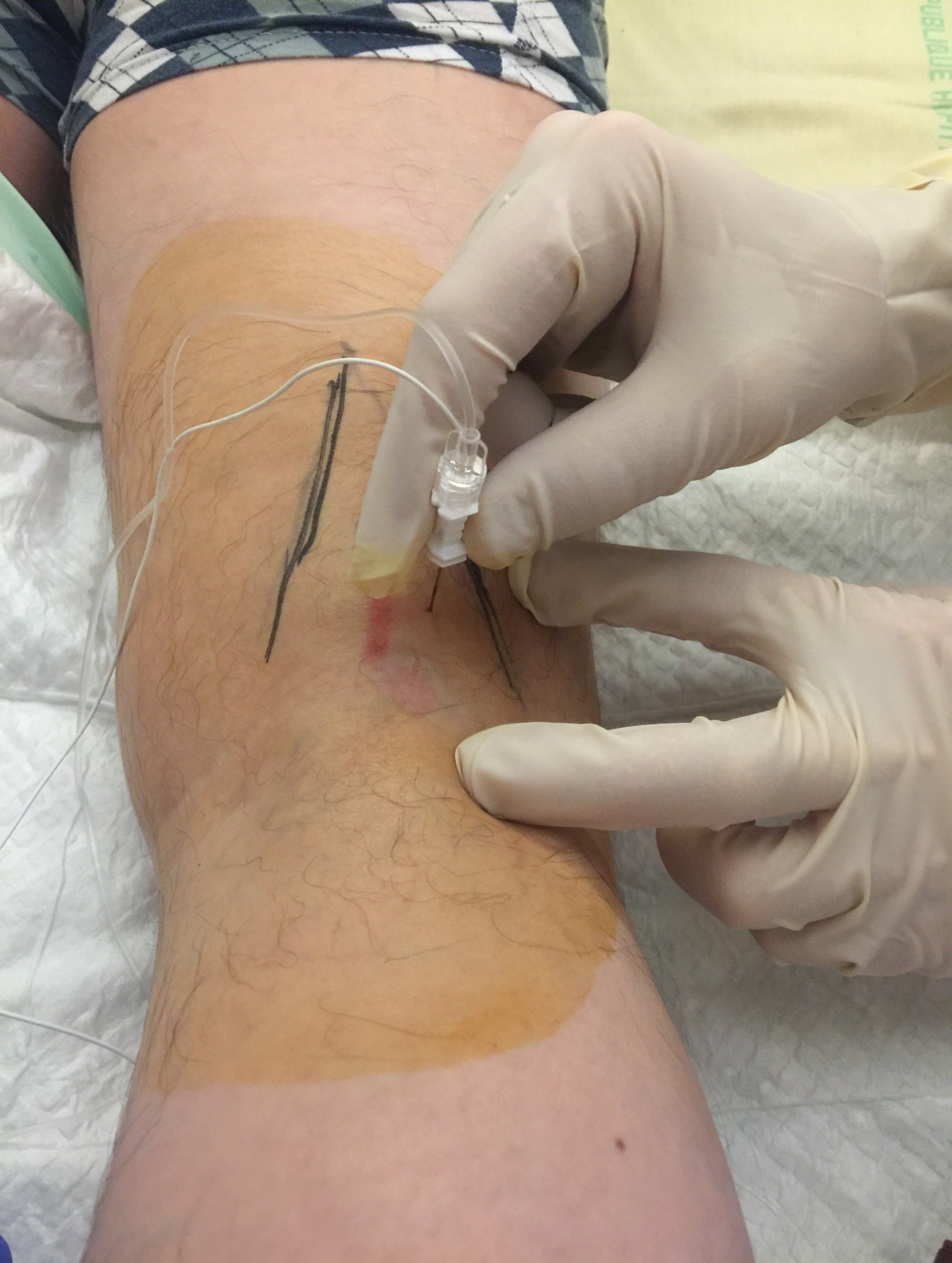


Table 1: percentages of approval among the 16 experts.
Columns represent sub-questions in each guideline. Percentages represent the level of agreement (answer rated as 7, 8 or 9)

	1	**2**	**3**	**4**	**5**
Guideline 1	88%	81%	88%	69%	-
Guideline 2	2.1.1, 2.1.2 and 2.1.3 = 88% 2.1.4 = 93%	81%	2.3.1 = 93% 2.3.2 = 81%	-	-
Guideline 3	93%	93%	-	-	-
Guideline 4	93%	88%	93%	-	-
Guideline 5	93%	93%	93%	93%	93%
Guideline 6	93%	93%	93%	93%	93%
Guideline 7	93%	88%	93%	93%	-
Guideline 8	93%	93%	93%	-	-

Table 2: Overview of the different nerve blocks of the upper-limb.
The table presents each nerve, muscles they innervate, clinical indications of blocks, and additional indices of physiological efficacy (other than decrease of muscle hypertonia).

Nerve	Type	Motor Innervation	Indications	Additional Efficacy Criterion
Pectoral	Motor	Pectoralis major Pectoralis minor	Attitude in adduction, and medial rotation of the shoulder (Pectoralis major) Antepulsion of the shoulder stump (Pectoralis minor)	None (no skin anesthesia)
Musculocutaneous	Mixed	Coracobrachialis Biceps brachialis Brachialis	Flexion of the elbow	Depressed bicipital reflex Anesthesia at the lateral edge of the forearm
Median	Mixed	Pronator teres and quadratus Flexor carpi radialis Palmaris longus Flexor digitorum superficialis Flexor digitorum profundus (second and third fingers) Flexor pollicis longus Intrinsic muscles of the thumb (except deep muscle bundle of the Flexor pollicis brevis and abductor brevis)	*At the Elbow:* Forearm pronation, wrist flexion, and fingers flexion *At the Wrist:* Isolated hypertonia of the muscles of the thenar eminence of the hand (thumb in the palm)	Cutaneous anesthesia of the thenar eminence, of the palmar face of the first 3 fingers
Ulnar	Mixed	Flexor carpi ulnaris Flexor digitorum profundus (fourth and fifth fingers) Opponens digiti minimi, abductor digiti quinti Flexor digiti minimi Adductor pollicis Deep muscle bundle of the Flexor	*At the Elbow*: flexion and ulnar deviation of the wrist. Flexion of the metacarpophalangial joints *At the Wrist*: Flexion of the metacarpophalangial joints, closing of the first web contracture, ulnar	Cutaneous anesthesia of the hypothenar eminence and the fifth finger.

pollicis brevis	deviation of the fingers
Palmar and dorsal interossei, lumbricals (third and fourth)	

Table 3: Overview of the different nerve blocks of the lower-limb.
The table presents each nerve, muscles they innervate, clinical indications of blocks, and additional indices of physiological efficiency (other than improvement of muscle hypertonia).

Nerve	Type	Motor innervation	Indications	Additional Efficacy Criterion
Femoral (distal branches)	Motor	Rectus femoris Eventually : Vastus intermedius , Vastus medialis and vastus lateralis	Knee stiffness in extension during swing phase, no amortization at the beginning of the stance phase, anteversion of the pelvis when walking	Failure of leg extension (partial) Decreased of the patellar reflex No cutaneous anesthesia.
Obturator	Mixed	*Anterior branch* : Adductor longus, adductor brevis, gracilis, pectineus *Posterior branch* : Adductor magnus, adductor brevis	Adductum of the hip	Loss of sensitivity in the posterolateral part of the knee (Inconstant sensory innervation of the anterior branch)
Tibial - truncular at the popliteal fossa, - selective at the posterior part of the leg, - distal at the tarsal canal	Mixed	*Dorsal Compartment of the leg :* Triceps surae Tibialis postérior Flexor digitorum longus Flexor hallucis longus Plantar intrinsic muscles of the foot	Deformity of the foot in equine ± varus ± Toe claw Selective motor blocks : selective evaluation of the muscles of the dorsal leg compartment without sensory disturbance (medial and lateral gastrocnemius branchs, Soleus branch, Tibialis posterior branch and Flexor digitorum longus branch, Internal retromalleolar block)	Depression of the Achilles reflex (except for the distal motor nerve block) Cutaneous anesthesia of the sole of the foot (for truncular and distal blocks)