(Acta Anaesth. Belg., 2021, 72, 83-91)

The practice of regional anesthesia in Belgium – a national survey

P. Goffin (*), J.P. Lecoq (**), L. Sermeus (***)

Abstract : *Background :* National surveys are useful to assess the state of regional anaesthesia (RA) practice in a particular country. Given that such information was lacking in Belgium, we conducted a survey to evaluate the Belgian practice of peripheral nerve blocks (PNBs) with a particular focus on its safety aspects.
Methods: A survey was sent by email to 1510 Belgian anesthesiologists. No identifying information was collected. Data were collected between September 2019 and October 2019.
Results : We collected 324 questionnaires (response rate 21%). Eighty five percent of respondents perform regularly PNB. 99% place a venous access before performing a block, and more than 90% monitor patients with minimum peripheral pulse oximetry.
The majority monitor patients for a minimum of 30 minutes after the injection of local anesthetic (LA). Ultrasound-guided technique for RA is used by 89% of respondents. Neurostimulation is totally abandoned by 20% of them. Monitoring of injection pressures is performed by 21% of respondents. More than 50% of respondents use sterile gloves, surgical drapes and a mask. With regards to the solution of LA used, 52% of respondents never mix LAs. An adjuvant is always used by 15% of the respondents while 10% of them never use them.
Conclusions : This survey suggests that the practice of PNBs in Belgium is in line with the current international guidelines. This survey can serve as a benchmark for future evaluation and comparison between RA techniques. These observations should be taken into account for the implementation of national guidelines and therefore for the improvement of safety in the practice of PNBs.

Keywords : regional anesthesia ; practice ; local anesthetics ; Belgium.

Introduction

Regional anesthesia (RA) has become a cornerstone in clinical anesthesia practice and has clearly gained popularity over the past decade. The analgesic benefits of RA are well demonstrated and associated with patient and practitioner satisfaction. Recent interest in RA is related to the use of ultrasound (US). US has increased the effectiveness of peripheral nerve block (PNB) and has also been introduced more recently in neuraxial blocks. Ultra-sound-guided RA is associated with increased block success, patient satisfaction, and reduced risk of vascular puncture due to improved visibility of anatomic structures, needle or catheter and local anaesthetics (LA) spread. However, no reduction in the risk of local anesthetic systemic toxicity or neuropathy has been demonstrated with US-guided regional anesthesia (1). Since clinicians are aware of the benefits of US, RA techniques are routinely performed in many hospitals. Appropriate equipment and technique are the key to safe and effective RA (2).

Despite extensive scientific recommendations (1, 3), little is known about current clinical practice and, more specifically, there are no data on the organization and current practice of RA in Belgium. Where and under what conditions are RA techniques performed? Are safety rules applied? Which nerve approach is used? Which LA is injected? What are the adjuvants? Are PNBs used continuously? What about RA in children?

To gather this information, we designed an online survey of Belgian anesthesiologists. Indeed, national surveys are an interesting tool to assess practice in a country, and more specifically to highlight barriers to adherence or implementation of national guidelines (3).

Pierre Goffin, MD, MSc ; Jean-Pierre Lecoq, MD, PhD ; Luc Sermeus, MD, PhD.
(*) Department of Anesthesiology and Intensive Care, MontLégia Hospital, Groupe Santé CHC, Liège, Belgium
(**) Department of Anaesthesiology and Intensive Care, University Hospital of Liège, Liège, Belgium
(***) Department of Anesthesiology; Saint-Luc University Hospital, Brussels, Belgium
Corresponding author : Dr Pierre Goffin, MontLégia Hospital, Av Patience et Beaujonc 2, 4000 Liège, Belgium.
Email : pierre.goffin@chc.be

Paper submitted on November 1, 2020 and accepted on March 26, 2021
Conflicts of Interest: The authors declare no conflicts of interest.
Funding: The authors have no sources of funding to declare for this manuscript.
An abstract is presented at Euroanesthesia 2020 in November 2020 (ESAIC annual virtual meeting, submission reference 4868).

National guidelines for safety in anesthesia in Belgium and specific guidelines for RA are published by the Belgian Society of Anesthesiology, Resuscitation, Perioperative medicine and Pain management (BeSARPP)(4), and BARA (Belgian Association for Regional Anaesthesia) (3) respectively, and are regularly updated. This survey was conducted to evaluate the Belgian practice of PNB with a particular focus on its safety aspects. The answers to this survey may be useful for the updating of future Belgian guidelines for regional anesthesia.

Methods

The survey was sent by e-mail to Belgian anesthesiologists included either in the BARA mailing list or in the mailing list of Belgian university hospital network via BeSARPP. Thus, almost all anesthetists who graduated from a Dutch- or a French-speaking university in Belgium received this mail. Anesthesiologists with foreign training were omitted, unless they were members of BARA. Some anesthesiologists may have received the mail twice. Respondents completed the survey via the SurveyMonkey® online platform (SurveyMonkey Inc., San Mateo, California, USA, www.surveymonkey.com). The survey was anonymous and no identifying information was collected. Data were collected for six weeks between September 2019 and October 2019. A first reminder was conducted at the 19th BARA meeting (October 3, 2019, Brussels). A second reminder was sent via mail.

The survey consists of 44 questions and takes about 15 minutes to complete. The survey is divided into four parts. The first part of the survey concerns demographics and professional practice data, level of education and training, practitioner competence, and daily practice of RA. The second part concerns safety rules: use of sedation during the performance of RA, asepsis rules, location of RA performance, availability of assistance for the anesthesiologist, type of monitoring used, presence of an intravenous line, and exact location of Intralipid in the facility. The third part of the survey assessed the technique of nerve block, the type of LA and/or adjuvant used. Some questions concern LA used in children or in ambulatory care. The last part of the survey concerns the postoperative follow-up. Most responses used a Likert scale of three to five items, with some requiring only one number. Respondents were able to send remarks and comments via the platform.

Statistical analysis

This study is considered descriptive and exploratory. Therefore, the results of this survey are presented using descriptive statistics. For responses associated with a Likert Scale, responses are evaluated using the percentage for each data item. Data are recorded in a Microsoft Excell sheet.

Results

Of the 1510 anesthesiologists to whom the survey was sent, 324 questionnaires were enrolled, for a response rate of 21.4%. Two hundred and seventy-eight questionnaires were fully completed and used for analysis.

Demographics and professional practice data

Demographic data are represented in Table 1 and Figure 1. Most respondents are active nearly full-time active with an average of 8.7 half-days of practice per week (95% CI 8.4-9.0). Forty-eight percent of respondents are only active as – an anesthesiologist –. Respectively, 6.5%, 29%, and 16.5% of respondents work part-time in an emergency department, intensive care unit or pain clinic. The distribution of year of graduation is shown in Figure 2. Seventy-five percent of

Table I

Responders characteristics

Characteristics	%
1. Laguage	
Dutch	51.3
French	48.7
2. Type of hospital	
University hospital	30
Community hospital	70
3. Clinical activity	
Anesthesia only	48
Anesthesia and ICU	29
Anesthesia and ER	6.5
Anesthesia and pain clinic	16.5
4. Level of education	
Certified anesthesiologist	83.2
Trainee	16.8
5. Training in RA	
Only during residency	75
Additional training course	11.7
Workshop	55
Self-leaning	49
6. Proportion of RA activity	
Daily practice	38
Weekly practice	46.6
Occasional practice	15.3

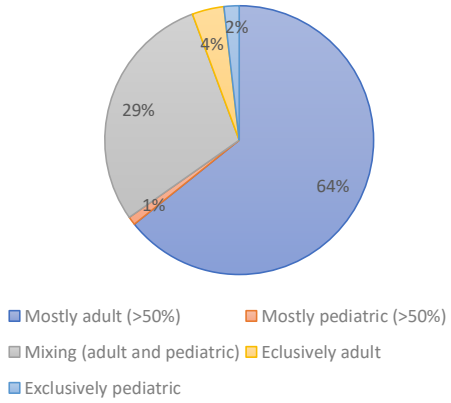

Fig. 1. – Area of activity of responders.

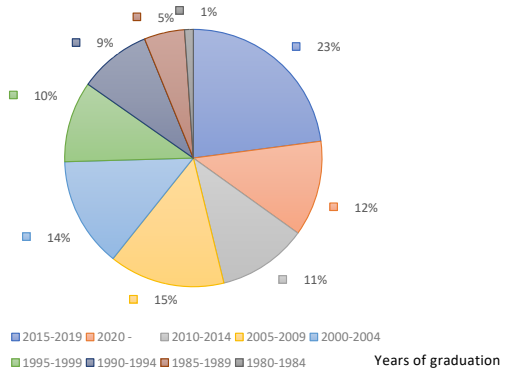

Fig. 2. – Anesthesia graduation year of responders.

respondents graduated as anesthesiologists after 2000. Eighty percent of respondents practice RA regularly (at least once a week). With regard to training in RA, 75% of respondents acquired RA skills during their anesthesia residency and 11.7% attended specific training courses. Continuing education in RA was obtained through conferences, dedicated workshops, and self-study for 31%, 55% and 49% of respondents, respectively.

Safety measures

35% of the respondents performed RA in the operating room and 36% in the recovery room. A dedicated RA room is used in 27% of institutions. Only 2% of the respondents reported that they perform the RA technique outside the operating room.

Sterility rules

Figure 3 shows the measures taken for sterility. More than 50% of respondents use sterile gloves, surgical drapes, and a surgical cap when performing PNBs.

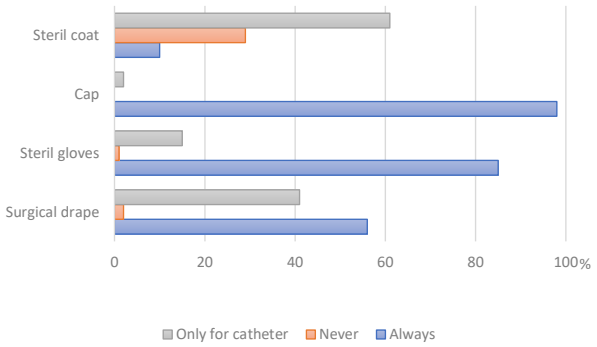

Fig. 3. – Measures taken for sterility.

Monitoring

Ninety-nine percent of anesthesiologists place venous access. Ninety-three percent perform RA using partial or complete standard monitoring. Of the means used to monitor patients, peripheral pulse oximetry is used in 99% of the time, pulse oximetry is combined with ECG in 60% of the time, and ECG and NIBP 55% of the time. Most anesthesiologists keep patients monitored for a least 30 minutes after LA injection, whereas 8% of respondents keep patients only under visual observation near the operating room.

Premedication or anesthesia

Sixty-one percent of anesthesiologists perform RA in adults without premedication, 20% with oral premedication (most often a low dose of benzodiazepine), 17.5% with mild intravenous sedation and 1.5% always perform RA under general anesthesia. Some respondents report the use of a hypnosis technique or virtual reality goggles. Half of the respondents perform local skin infiltration.

Most anesthesiologists (85%) perform the blocks before induction of general anesthesia, but in 15% of cases, RA is performed at the end of surgery for postoperative analgesia only.

LA toxicity

Most practitioners (97%) know where intralipid is stored, and 93% of them confirm that it is in or near the operating room. In 4% of cases, it is stored in the emergency department and in 3% in the pharmacy department. Eighty-three percent of respondents report that a flash card as a cognitive aid is available near where the intralipid is stored.

Nerve block technique

Eighty-nine percent of anesthesiologists use an ultrasound-guided RA-technique, while 20% of respondents are able to perform blocks without the use of ultrasound, if the device is not directly available.

Neurostimulation is not used by 20%. Of those who use neurostimulation, 44% look for a motor response while 56% use it in sentinel mode with a mean minimum intensity of 0.44 mA (95% CI 0.40-0.46). Monitoring of injection pressures is performed systematically by 10.5% of anesthesiologists, whereas 79.5% of them do not have this monitoring in their institution or are unaware of its existence.

For 45% of respondents, the in-plane approach is the only technique used. For the others, the choice between an in-plane or out-of-plane approach depends mainly on the block. The extra-neural approach is used in 75% of cases. LA solutions are injected by an assistant, such as nurse or resident, in 85.5% of cases.

Local anesthetics solutions and adjuvants

Different parameters influence the type, volume, and concentration of the LA used. The main arguments influencing the choice are outpatient surgery (80%), major postoperative pain (89%) and avoidance of catheter placement (87%).

Regarding long-acting LAs, 19.8% of respondents never use ropivacaine and 34% of them never use levobupivacaine. Eight different concentrations of ropivacaine and four concentrations of levobupivacaine were reported to be used in adults (Figures 4 and 5). The mean dose used for a single shot injection is 2.74 mg/kg (CI 95% 2.55-2.94) for ropivacaine and 2.63 mg/kg (CI 95% 2.44-2.83) for levobupivacaine.

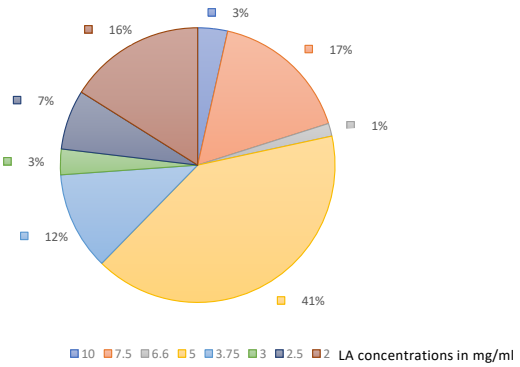

Fig. 4. – Proportion of ropivacaine used in adults (LA concentration expressed in mg/ml).

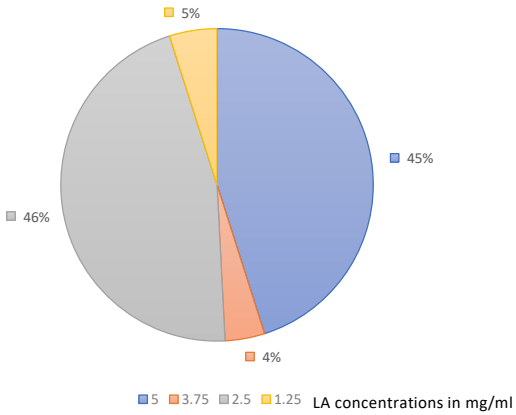

Fig. 5. – Proportion of levobupivacaine used in adults (LA concentration expressed in mg/ml).

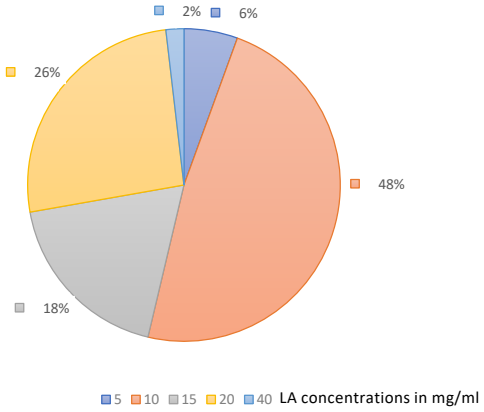

Fig. 6. – Proportion of lidocaine-adrenaline used in adults (LA concentration expressed in mg/ml).

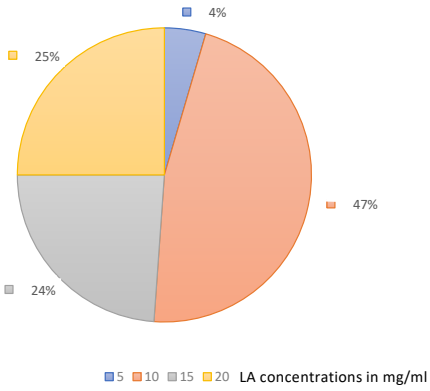

Fig. 7. – Proportion of mepivacaine used in adults (LA concentration expressed in mg/ml).

For short-acting LAs, lidocaine and mepivacaine are never used by 65.5% and 58% of respondents, respectively. The concentrations used are shown in Figures 6 and 7.

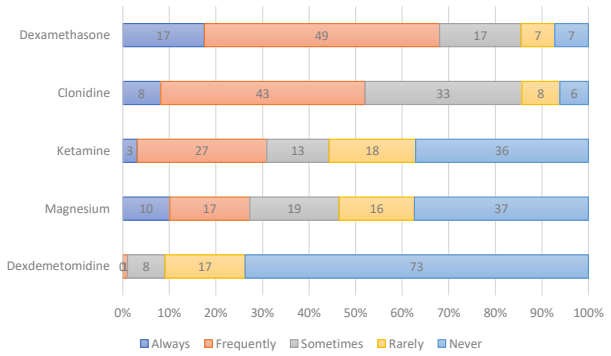

Fig. 8. – Different adjuvants used in adults and relative frequencies.

Mixing LAs is fairly common for 48% of anesthesiologists, with wide variability in the types and concentrations of mixing.

Adjuvants (mixed with the LA solution) are routinely used by 15% of respondents, while 19% never use adjuvants. Details regarding adjuvants are described in Figure 8. Perineural dexamethasone is the most commonly used adjuvant. The goals of adjuvant use are to potentiate analgesia (93%), reduce rescue analgesia (62%), decrease the amount of LA used (33%), provide opioid-free analgesia (30%) and promote a smooth recovery (21%).

RA in pediatric patients

In pediatric patients, RA is performed in 65% of cases under general anesthesia and in 14.5% of cases under light sedation. A few respondents report the use of the video distraction technique when performing RA in children.

Ropivacaine is used in 62% of pediatric cases, with seven different concentrations reported (Figure 9). The mean dose of LA injected is 2.2 mg/kg (95% CI 2.01-2.54). The volume used is 1 ml/kg for 32% of the anesthetists, less than 1 ml/kg for the others.

Levobupivacaine is preferentially used in children by 38% of anesthesiologists with five different concentrations (Figure 10). The average dose of LA is injected 1.8mg/kg (95% CI 1.31-2.40). The volume used is 1 ml/kg for 60% of anesthetists, less than 1 ml/kg for the others.

Adjuvants are never added in the vast majority of blocks (59%). Details of the adjuvants are presented in figure 11.

Postoperative follow-up

For outpatient surgery, postoperative follow-up is ensured by a telephone contact by a nurse in 48% of cases or by an anesthetist in 3% of cases. There is no follow-up contact in 48% of cases.

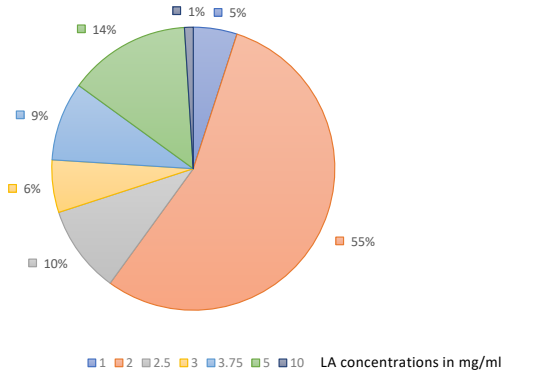

Fig. 9. – Proportion of ropivacaine used in pediatrics (LA concentration expressed in mg/ml).

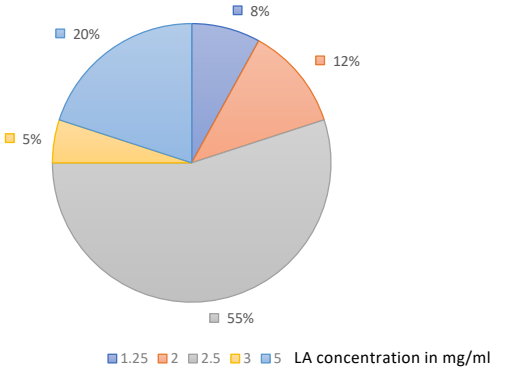

Fig. 10. – Proportion of levobupivacaine used in pediatrics (LA concentration expressed in mg/ml).

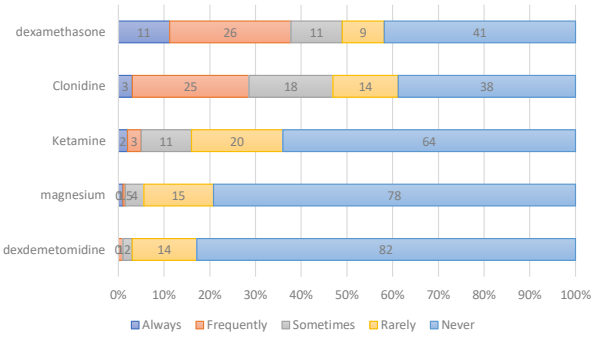

Fig. 11. – Different adjuvants used in pediatrics and relative frequencies.

Inpatients are visited either by an anesthetist (or a resident) in 41% of cases, or by a pain nurse in 38% of cases. Post-operative care is provided by the surgical team in 22% of cases.

Discussion

This survey is representative of the practice of RA in Belgium and can serve as a reference for discussions on future guidelines.

Our respondent population is made up of anesthesiologists with regular practice of RA, since

85% of them perform RA regularly. In addition, 16% of anesthesiologists work in a pain clinic where ultrasound guided techniques are routinely performed. It is likely that this population of dedicated anesthesiologists is more convinced of the benefits of RA and may have introduced a bias in our results.

One-third of the respondents graduated from anesthesia within the past decade. This period has been marked by a growing enthusiasm for RA related to the introduction of ultrasound as a nerve localization technique. As such, this younger generation could be positively influenced by this new and exciting method. Older anesthesiologists have had to adapt their RA knowledge and practice because of the introduction of US-guided RA. Our survey showed that 75% of respondents have learned about RA during their residency. They need to update their knowledge with conferences, workshops, and self-study. Only 11.7% of respondents have taken a course dedicated to RA. Scientific societies and universities need to be aware that half of our respondents are self-taught. The organization of specific learning programs is therefore mandatory.

According to this survey, 35% of the blocks are performed in the operating room. It has been demonstrated that a dedicated RA room is associated with better efficiency and probably a better clinical outcome (5). Unfortunately, the exact proximity, between this specific block room and the operating room, was not studied in our survey. If the two area are too far from apart, safety issues may arise. According to the Declaration of Helsinki on Patient Safety in Anesthesiology, all patients receiving perioperative anesthesia should be monitored (6). Hadzic recommends the use of pulse oximetry, ECG monitoring and NIBP (7). We observed that 55% of respondents comply with this safety recommendation. The majority of anesthesiologists keep patients monitored for at least 30 minutes after LA injection, which is consistent with the French safety rules (2).

Specific recommendations regarding aseptic precautions are lacking in the guidelines. Yet, anesthesiologists play a major role in preventing nosocomial infections. In RA techniques, the physiological barriers are broken, allowing contamination of the patient by microorganisms. The use of a mask, cap and gloves, and the use of surgical drapes are highlighted as the most important precautions for infection prevention when performing neuraxial blocks (8). The same recommendations exist for PNBs (9). In a series of pediatric RA from Australia and New Zealand, the majority of anesthetists used sterile gloves and half used sterile drapes (10). In our survey, more than 50% of respondents used a complete set (cap - mask - gloves - surgical drapes), which means they are above the average for aseptic precautions described in pediatrics in comparison with other guidelines.

Our survey shows that lipid emulsion is directly available near the OR in more than 90% of cases. A flash card with a resuscitation protocol for Local Anesthetic Systemic Toxicity (LAST) is frequently available near the Intralipid storage location. The availability of this flash card is crucial, as resuscitation of cardiac arrest resulting from LAST has certain peculiarities (11).

Ultrasound guidance is widely used by the respondents and the availability of US is, for most of them, mandatory to perform a PNB. Only 20% of anesthesiologists can perform blocks without the use of ultrasound. US-guided RA reduces the incidence of vascular puncture, the risk of LAST or pneumothorax. There is no evidence, yet that US guidance reduces the incidence of peripheral nerve injury. Ultrasound is associated with a more comfortable procedure, faster sensory onset, lower LA doses, and also sometimes better quality of the block, without affecting its duration (1).

Eighty percent of respondents use dual guidance to perform their blocks. Nerve stimulation combined with US decreases the risk of paresthesia (12) and should therefore theoretically reduce the risk of nerve lesions. The practice of dual guidance has been reported in Switzerland (13), in China (14) and probably by less experienced anesthetists. In the present survey, nerve stimulation combined with US was used by about half of the respondents to seek for a motor response and by the other half as a sentinel to reduce the risk of intraneural needle penetration. Use of the technique as a sentinel was found to be reliable in reducing the risk of LAST (15) but was not associated with a reduction in nerve injury (16). A low-intensity motor response (less than 0.2 mA) is an indicator of possible intraneural needle penetration (17). The stimulation threshold used is well above the recommended threshold of 0.2 mA. However, some authors propose a safer approach by using nerve stimulation during ultrasound-guided nerve blocks at a fixed current of 1.0 mA (0.1 ms) with no change during block performance (18).

Pressure monitoring is rarely used. Data suggest that injection pressure is consistently higher during intrafascicular injection compared to extrafascicular injection (19). However, injection pressure values measured in the injection line are unlikely to reliably indicate injection pressures at

the needle tips (20). There is, in fact, low-quality evidence supporting the use of injection pressure monitoring to prevent nerve injury (19).

Ultrasound-guided RA with an in-plane approach only was performed by 45% of respondents. The choice of in-plane or out-of-plane approach has no effect on block efficiency. But control of the needle tip may be more challenging in the out-of-plane approach and needle-nerve contact may be more frequent (21).

Maximum recommended LA dose limits are met. Respondents remain below the limits of 2-3mg/kg of levobupivacaine or ropivacaine as recommended by Eisenberg (22). The choice of LA appears to be a complex decision. We observed that ropivacaine was the first choice in 80% of adults and 62% of children This may be explained by the large safety margin of ropivacaine compared with other long- acting LAs (13) or by pharmaceutical company lobbying's. The LA concentration rarely exceeded 0.5%. This seems acceptable in terms of myotoxicity (14) and neurotoxicity (15). In pediatric RA, most anesthetists use a concentration of 0.2% ropivacaine according to recently published recommendations (23).

Nearly 50% of respondents mix different LAs. Mixing LAs is no longer recommended in recent guidelines (24). The presumed benefits of mixing LAs, such as shorter onset of action and better block success could not be demonstrated. In addition, clinicians should be aware of potential additive toxic effects. If LAs are mixed, the total dose of the long-acting drug should be limited below the maximum recommended conventional dose (25).

A plethora of adjuvants have been used to prolong peripheral nerve block. They may accelerate the onset of peripheral nerve block, improve quality, and increase duration of analgesia (26). Opioids, alpha agonists, vasoconstrictors, steroids, electrolytes, and anti-inflammatory medications have been used as adjuvants to PNB. However, no adjuvant has been approved by the US Food and Drug Administration (FDA) as an additive to LA for PNB. Fifteen percent of those surveyed always used adjuvants and 10% never used them. Dexamethasone and clonidine were the most commonly used adjuvants, in both adults and children. However, alpha-agonists are the only adjuvant recommended in the ESRA pediatric guidelines (23) because of limited data regarding toxicity in children. Alpha-agonists and dexamethasone do not appear to induce local neurotoxicity (27). The results of this survey demonstrate that anesthetists use adjuvants to potentiate analgesia. Ropivacaine and levobupivacaine were the most commonly used LAs in the pediatric population. This practice is consistent with LA's in European Countries recently observed in the APRICOT study (28).

Regional anesthesia can be a stressful experience, and all measures to establish and maintain patient comfort and safety should be considered. The goal of these measures is to have a relaxed patient, comfortable, and cooperative throughout the execution of the block, without compromising safety (4). We observed that one-third of anesthesiologists use premedication and half infiltrate the skin with LA to ensure patient comfort. RA was performed under general anesthesia in 1.5% of the adult population and in 65% of the pediatric population. This practice in the pediatric population does not appear to be associated with more complications (29).

Patients scheduled for RA technique should benefit of the same postoperative care as those who received general anesthesia (30). As perioperative physicians, anesthetists are assuming increasing responsibility for patient care in the postoperative period. Surprisingly, we observed that nearly 50% of patients do not have any contact with an anesthetist after RA. Systems must ensure that anesthesiologists' knowledge is used to optimize patient care after surgery and to provide guidance to nurses and patients (31). The scope is broad but providing postoperative analgesia is a minimum, especially with continuous techniques. In addition, post-RA care remains an important part of the medicolegal involvement. While postoperative neurologic symptoms and nerve damage after RA are very rare (0-0.8% of patients at 6 months) (32), identification and follow-up of any injury is very important. A postoperative contact can inform about any type of complication or abnormality related to the anesthesia.

These observations suggest that PNBs practice in Belgium is consistent with recent French (2) and Belgian (24) guidelines. Compared to these recommendations, the practices described by respondents are consistent with a higher degree of safety.

This survey has some limitations. Probably the most important is the low response rate and the risk of bias due to the quality of the respondents. They have practiced RA regularly, and therefore have a great deal of experience and enthusiasm for this technique. This possible selection of respondents was the main limitation in interpreting the results. Second, the study protocol allowed only closed-ended responses. Some questions represent habits and customs and are affected by context.

It appears that some views depend on geographic region. We deliberately did not focus on regional variation in habits given the relatively small size of our country.

Some responses raised concern related possible misinterpretation; for example 25% of respondents performed a intrafascicular injection, which is not recommended (33). This surprisingly high response rate may reflect a misinterpretation or understanding of the question. Other responses may have been influenced by the same problem.

Conclusion

This survey is a picture of the practice of RA in Belgium and suggests that the practice of PNBs in Belgium is in line with current international guidelines. This survey can serve as a reference for future evaluation and comparison of RA techniques. These observations should be considered for the implementation of national guidelines and thus for the improvement of safety in PNBs practice.

References

1. Neal JM, Brull R, Horn J-L, Liu SS, McCartney CJL and Perlas A, et al. 2016. The Second American Society of Regional Anesthesia and Pain Medicine Evidence-Based Medicine Assessment of Ultrasound-Guided Regional Anesthesia: Executive Summary. Reg Anesth Pain Med. 41(2):181-94.
2. Carles M, Beloeil H, Bloc S, Nouette-Gaulain K, Aveline C and Cabaton J, et al. 2019. Anesthésie loco-régionale périnerveuse (ALR-PN). Anesthésie & Réanimation. Mar;5(3):208-2017.
3. Sermeus L, Pirson A, Breebaart B, Decoster J, Dereeper E and Gautier P, et al. 2013. Clinical guidelines for the practice of peripheral nerve blocks in the adult. Acta Anaesthesiol Belg.;64(3):105-8.
4. SARB and BSAR-APSAR. 2020. Belgian standards for patient safety in anesthesia. Revision 2019 of the last version published in the Acta Anaesthesiologica Belgica. Acta Anaesthesiol Belg. (71):5-14.
5. El-Boghdadly K, Nair G, Pawa A and Onwochei DN. 2020. Impact of parallel processing of regional anesthesia with block rooms on resource utilization and clinical outcomes: a systematic review and meta-analysis. Reg Anesth Pain Med. Sep;45(9):720–6.
6. Mellin-Olsen J, Staender S, Whitaker DK and Smith AF. 2010. The Helsinki Declaration on Patient Safety in Anaesthesiology. Eur J Anaesthesiol [Internet]. 27(7):592-7. Available from: http://europepmc.org/abstract/MED/20520556
7. Hadzic A. 2017. Hadzic's Textbook of Regional Anesthesia and Acute Pain Management. second ed. McGraw-Hill Professional, editor. New York:1537 p.
8. Practice Advisory for the Prevention, Diagnosis, and Management of Infectious Complications Associated with Neuraxial Techniques: An Updated Report by the American Society of Anesthesiologists Task Force on Infectious Complications Associated with Neurax. Anesthesiology. 2017 Apr;126(4):585-601.
9. Schulz-Stübner S, Pottinger JM, Coffin SA and Herwaldt LA. 2008. Nosocomial infections and infection control in regional anesthesia. Acta Anaesthesiol Scand. Sep;52(8):1144-57.
10. Fahy CJ, Costi DA and Cyna AM. 2013. A survey of aseptic precautions and needle type for paediatric caudal block in Australia and New Zealand. Anaesth Intensive Care. Jan;41(1):102-7.
11. Neal JM, Woodward CM and Harrison TK. 2018. The American Society of Regional Anesthesia and Pain Medicine Checklist for Managing Local Anesthetic Systemic Toxicity: 2017 Version. Reg Anesth Pain Med. 43(2):150-3.
12. Bomberg H, Wetjen L, Wagenpfeil S, Schöpe J, Kessler P and Wulf H, et al. 2018. Risks and Benefits of Ultrasound, Nerve Stimulation, and Their Combination for Guiding Peripheral Nerve Blocks: A Retrospective Registry Analysis. Anesth Analg. Oct;127(4):1035-43.
13. Luedi MM, Upadek V, Vogt AP, Steinfeldt T, Eichenberger U and Sauter AR. 2019. A Swiss nationwide survey shows that dual guidance is the preferred approach for peripheral nerve blocks. Sci Rep. (June):1-8.
14. Huang J and Gao H. 2016. Regional anesthesia practice in China: a survey. J Clin Anesth. Nov;34:115-23.
15. Orebaugh SL, Williams BA, Vallejo M and Kentor ML. 2009. Adverse outcomes associated with stimulator-based peripheral nerve blocks with versus without ultrasound visualization. Reg Anesth Pain Med. 34(3):251-5.
16. Orebaugh SL, Kentor ML and Williams BA. 2012. Adverse outcomes associated with nerve stimulator-guided and ultrasound-guided peripheral nerve blocks by supervised trainees: update of a single-site database. Reg Anesth Pain Med. 37(6):577-82.
17. Liu SS, YaDeau JT, Shaw PM, Wilfred S, Shetty T and Gordon M. 2011. Incidence of unintentional intraneural injection and postoperative neurological complications with ultrasound-guided interscalene and supraclavicular nerve blocks. Anaesthesia. Mar;66(3):168-74.
18. Ertmer M, Klotz E and Birnbaum J. 2017. The concept of protective nerve stimulation for ultrasound guided nerve blocks. Med Hypotheses. Sep;107:72-3.
19. Sen S, Ge M, Prabhakar A, Moll V, Kaye RJ and Cornett EM, et al. 2019. Recent technological advancements in regional anesthesia. Best Pract Res Clin Anaesthesiol. Dec;33(4):499-505.
20. Saporito A, Quadri C, Kloth N and Capdevila X. 2019. The effect of rate of injection on injection pressure profiles measured using in-line and needle-tip sensors: an in-vitro study. Anaesthesia. Jan;74(1):64-8.
21. Ruiz A, Sala-Blanch X, Martinez-Ocón J, Carretero MJ, Sánchez-Etayo G and Hadzic A. 2014. Incidence of intraneural needle insertion in ultrasound-guided femoral nerve block: a comparison between the out-of-plane versus the in-plane approaches. Rev Esp Anestesiol Reanim. Feb;61(2):73-7.
22. Eisenberg É and Gaertner E. 2014. Échographie en anesthésie régionale, médullaire et périmédullaire. second ed. Arnette, editor. John Libbey Eurotext; 339 p.
23. Suresh S, Ecoffey C, Bosenberg A, Lonnqvist P-A, de Oliveira Jr GS and de Leon Casasola O, et al. 2018. The European Society of Regional Anaesthesia and Pain Therapy/American Society of Regional Anesthesia and Pain Medicine Recommendations on Local Anesthetics and Adjuvants Dosage in Pediatric Regional Anesthesia. Reg Anesth Pain Med. Feb;43(2):211-6.
24. Desmet Mathias. 2020. Clinical guidelines for the practice of peripheral nerve blocks in the adult. Acta Anaesthesiol Belg. 71:151-61.
25. Thangaswamy CR and Elakkumanan LB. 2009. Maximum Recommended Dose for Local Anesthetic Mixture. Anesth Analg. 108(2):669.

26. Swain A, Nag DS, Sahu S and Samaddar DP. 2017. Adjuvants to local anesthetics: Current understanding and future trends. World J Clin cases. Aug 16;5(8):307-23.
27. Knight JB, Schott NJ, Kentor ML and Williams BA. 2015. Neurotoxicity of common peripheral nerve block adjuvants. Curr Opin Anaesthesiol. Oct;28(5):598-604.
28. Dadure C, Veyckemans F, Bringuier S and Habre W. 2019. Epidemiology of regional anesthesia in children: Lessons learned from the European Multi-Institutional Study APRICOT. Pediatr Anesth. Nov 1;29(11):1128-35.
29. Walker BJ, Long JB, Sathyamoorthy M, Birstler J, Wolf C and Bosenberg AT, et al. 2018. Complications in Pediatric Regional Anesthesia: An Analysis of More than 100,000 Blocks from the Pediatric Regional Anesthesia Network. Anesthesiology. Oct;129(4):721-32.
30. Adergal A. 2008. Responsabilité civile en anesthésie-réanimation. Droit, Déontologie Soin. 8(4):418-51.
31. Sultan P, Jigajinni S, Mcglennan A and Butwick A. 2011. The postoperative anaesthetic review. J Perioper Pract. 4:135-9.
32. Hewson DW, Bedforth NM and Hardman JG. 2018. Peripheral nerve injury arising in anaesthesia practice. Anaesthesia. 73:51-60.
33. Franco CD and Sala-Blanch X. 2019. Functional anatomy of the nerve and optimal placement of the needle for successful (and) safe nerve blocks. Curr Opin Anaesthesiol. 32(5):638-42.