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REPORTS OF ORIGINAL INVESTIGATIONS

# Environmental responsibility in resource utilization during the practice of regional anesthesia: a Canadian Anesthesiologists' Society Delphi consensus study

# La responsabilité environnementale dans l'utilisation des ressources pendant la pratique de l'anesthésie locorégionale : une étude consensuelle par la méthode Delphi de la Société canadienne des anesthésiologistes

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## Abstract

**Purpose** *Regional anesthesia (RA) is often perceived to be more environmentally sustainable than alternative forms of anesthesia. Nevertheless, the principles of sustainable RA remain ill-defined in the presence of variability of resource utilization within RA practice. Many infection prevention practices are based on low-level evidence, and recommendations vary internationally. We sought to conduct an evidence review and Delphi consensus study to provide guidance on aspects that lack high-quality evidence in RA practice to reconcile responsible resource stewardship and infection prevention in RA.*

**Methods** *We conducted a three-round modified Delphi process. After distributing an initial free-text questionnaire to all collaborators, we created structured questions, followed by two rounds of anonymized voting. We defined strong consensus as* $\geq$ *75% agreement and weak consensus as* $\geq$ *50% but* $<$ *75% agreement.*

The members of the Collaborators are provided in the Acknowledgements section.

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**Results** *Forty-six experts agreed to take part in the study and 36 (78%) completed all the voting rounds. Regional anesthesia practice parameters with strong consensus included hand hygiene using alcohol scrub rather than soap and water, sterile gowns being unnecessary for single-injection RA techniques, only minimal equipment in the premade packs, and goal-directed use of sedation and supplemental oxygen.*

**Discussion** *We obtained consensus on the safe and environmentally responsible practice of RA for both single-injection and indwelling catheter techniques and identified areas of research focus. While more robust evidence is being generated, clinicians may use these findings as a guide to infection prevention and environmental sustainability in their anesthesia practice.*

**Résumé**

**Objectif** *L'anesthésie locorégionale (ALR) est souvent perçue comme étant plus durable sur le plan environnemental que les autres formes d'anesthésie. Néanmoins, les principes d'une ALR durable restent mal définis en présence de la variabilité de l'utilisation des ressources dans la pratique de l'ALR. De nombreuses pratiques de prévention des infections sont fondées sur des données probantes de faible niveau, et les recommandations varient à l'échelle internationale. Nous avons cherché à mener une revue des données probantes et une étude consensuelle Delphi afin de fournir des conseils sur les aspects qui manquent de données probantes de haute qualité dans la pratique de l'ALR afin de concilier la gestion responsable des ressources et la prévention des infections en ALR.*

**Méthode** *Nous avons mené un processus Delphi modifié en trois tours. Après avoir distribué un premier questionnaire en texte libre à tous les collaborateurs et collaboratrices, nous avons créé des questions structurées, suivies de deux tours de vote anonymes. Nous avons défini un consensus fort comme ≥ 75 % d'accord et un consensus faible comme ≥ 50 %, mais < 75 % d'accord.*

**Résultats** *Quarante-six expertes et experts ont accepté de participer à l'étude et 36 (78 %) ont terminé tous les tours de vote. Les paramètres de la pratique de l'ALR faisant l'objet d'un fort consensus comprenaient l'hygiène des mains à l'aide d'un gel alcoolisé plutôt qu'avec de l'eau et du savon, l'inutilité/la non-nécessité des blouses stériles pour les techniques d'ALR à injection unique, les kits préparés ne contenant que l'équipement minimal et l'utilisation ciblée de sédation et d'oxygène supplémentaire.*

**Discussion** *Nous avons obtenu un consensus sur la pratique sécuritaire et écoresponsable de l'ALR pour les techniques de cathéter à injection unique et à demeure et avons identifié des domaines d'intérêt pour la recherche. En attendant que des données probantes plus solides soient générées, les cliniciennes et cliniciens peuvent utiliser ces résultats pour les guider dans la prévention des infections et la durabilité environnementale dans leur pratique de l'anesthésie.*

**Keywords** anesthesia practice · Delphi study · environmentally responsible · regional anesthesia · resource stewardship · sustainable practice

Some literature exists on the scientific foundation of and consensus for environmentally sustainable anesthesia,[1–4] but none focuses specifically on the details of practice pertinent to regional anesthesia (RA) (i.e., peripheral nerve blocks [PNBs], interfascial plane blocks, neuraxial blocks), and none includes single-injection or indwelling catheter-based techniques. While RA is often thought to be more environmentally sustainable than general anesthesia, the variability in resource utilization of RA practice leads to a wide range of potential environmental impacts.[5]

Infection prevention guidelines and best-practice recommendations to reduce infectious complications are provided by many professional bodies in anesthesiology,[6–11] though the scientific foundation of some of these recommendations has been queried.[12]

Considering the need for responsible resource stewardship, we sought to conduct a Delphi study to seek consensus on an environmentally responsible clinical practice in RA, where robust and up-to-date evidence on the environmental impact of RA practice parameters is lacking.

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## Methods

### *Delphi process*

The project was supported and approved by the Canadian Anesthesiologists' Society Board of Directors. Formal ethical approval was not required as the results of the survey were used to develop a consensus, which did not meet the criteria for human participant research as per the ethics committee at the University of Alberta (Edmonton, AB, Canada). An international steering committee comprising experts in RA, obstetrical anesthesia, and environmental sustainability (R. S., C. S., F. M., D. E., T. O.) was convened by the lead author (V. I.) via existing professional networks. A modified Delphi consensus methodology[13] was adopted; the steering committee identified a panel of experts in fields relevant to the study based on relevant publications, conference presentations, or recommendations from professional groups and societies. The steering committee generated four open questions, which were then sent to all experts to aggregate ideas in an anonymous fashion about the barriers, facilitators, and practical aspects of environmentally sustainable practice in RA (Electronic Supplementary Material [ESM] eAppendix 1). We reviewed the medical literature for areas or domains where evidence was low quality or lacking and combined these with the results of the survey to generate a longlist of questions for voting. There were two rounds of electronic voting using structured closed questions (ESM eAppendices 2 and 3). Finally, there was an online comment round where experts were invited to freely and anonymously provide any further comments. Collaborators were explicitly informed of the strict response deadline of two weeks for each round of Delphi study. Any collaborators who did not complete any voting round or did not respond within the prescribed timeline were excluded from all subsequent rounds and the authorship of the final publication. The Figure shows the structure of the Delphi process and number of participants.

Consensus was defined *a priori* as $\geq$ 75% agreement, which is the median threshold for Delphi consensus studies.[14,15] The anonymized responses from each round were fed back in a summarized form to the participants before the next round commenced (ESM eTable 1).

### *Expert panel selection*

We invited 68 experts to participate in this Delphi consensus study. Six declined to participate and 16 did not respond to the invitation email. Forty-six experts (including the steering committee), subspecializing in RA, obstetric anesthesia, environmental sustainability, and infection control/microbiology, accepted the invitation to participate and all of them had extensive clinical, educational, and research experience or leadership roles in their subspecialty (Canada, 9; USA, 19; UK, 10; Australia, 4; France, 1; Greece, 1; Germany, 2).

### *Longlist generation*

After obtaining the response to the initial questionnaire round from the collaborators, the steering committee searched the MEDLINE database from 1946 to 1 December 2023 and augmented this with a Google search (via www.google.com) to identify any existing evidence for each theme and to capture relevant articles in the grey literature. The keywords used were "neuraxial," "epidural," "spinal," "anesthesia," "analgesia," "regional," "nerve blocks," "recycling," "environment," "sustainable," "anti-infective agents," "infection control," as well as various guidelines and practice advisories from anesthesiologists' professional societies and organizations. The full list of search strategies can be found in ESM eTable 2. We included the techniques and practices of RA pertaining to infection control without robust supportive evidence in the longlist.

### *Voting rounds*

Both round 1 and 2 voting were conducted using Google Forms (Alphabet Inc., Mountain View, CA, USA) distributed to all collaborators via email, with clear instructions to fill in the form. We sent the longlist of closed questions to all collaborators and invited them to state their level of agreement according to three options: "Yes," "No," or "Unsure." Participants were able to provide qualitative feedback, additional comments, or relevant references within the same form.

The project administrator collated and anonymized all responses from both rounds prior to analysis by the steering committee. The criteria for round 1 were:

- $\geq$ 50% agreement: included in the subsequent round
- $<$ 50% agreement: excluded from subsequent rounds

The steering committee reviewed questions without "strong consensus" ($<$ 75% but $\geq$ 50%) and revised them for clarity if necessary, before including them in round 2. Any additional questions suggested via the comments section in round 1 were also included in round 2 (ESM eAppendix 3).

The criteria for round 2 were:

- $\geq$ 75% agreement: accepted as having "strong consensus" and included without further voting
- $<$ 50% agreement: excluded
- 50–74% agreement: defined as "weak consensus" and included in round 3

In round 3, collaborators who completed all the previous rounds were encouraged to provide comments on the statements with weak consensus, freely and anonymously (ESM eAppendix 4). The strength of the consensus for these statements were not changed but the comments were considered.

*Statistical analysis*

Statistical analyses were descriptive only (no inferential statistics were applied). They correspond to the proportion of "Yes," "No," or "Unsure" answers. All denominators for percentages reported were the number of responses rather than participants.

## Results

Forty-six experts agreed to take part in this study. Of those who agreed, 44/46 (96%) responses were obtained from the initial questionnaire, 39/46 (85%) responses were obtained in round 1 voting, and 36/46 (78%) responses were obtained in round 2 voting.

*Round 1*

Five items did not have 50% agreement or more and were excluded after round 1 (ESM eTables 1 and 3). These were "scrub hat is required for PNB," the use of "aseptic nontouch technique can be adopted onto sterile site in spinal," "sterile gown requirement for epidurals," "sterile tray should be used as workspace in catheter techniques," and "microbial skin preparation spray (chlorofluorocarbon free) can be used rather than gauze/applicator, if available in all RA techniques." Although most participants thought that antimicrobial dressing should not be required for an epidural, the agreement was not sufficient to reach round 2. Also, the item of using less resource-intensive truncal block or PNB in place of neuraxial opioid did not have enough agreement and was excluded after round 1.

The items that were reworded for clarity for round 2 are detailed in ESM eTable 1.

*Round 2*

There were 65 items with practice parameters that reached strong consensus ($\geq$ 75%) and weak consensus ($\geq$ 50% and $<$ 75%) as listed in the Table. The practice parameters with strong consensus categorized into specific procedures can be found in ESM eTable 4.

*Strong consensus*

There was strong consensus that for spinal single injection, hands that are socially clean (i.e., without visible soiling or contact with body fluids) can be cleaned with alcohol scrub instead of soap and water to avoid using towels for drying. Sterile gloves, a scrub hat, and a face mask are required but not a sterile gown. The procedure site should be cleaned with an antimicrobial skin preparation and the sterile field should be draped. If a premade pack is used, only minimal common equipment shared by the group should be included. An ultrasound transducer cover is unnecessary unless real-time needling is used, in which case a full sleeve cover for both the ultrasound transducer and its cable is required for catheter insertion and spinal single injection.

For peripheral nerve block single injection, there was strong consensus that hands that are socially clean only need to be cleaned with an alcohol scrub. Furthermore, a sterile gown is not required. The nerve block site should be cleaned with an antimicrobial preparation but the sterile field does not need draping. An aseptic nontouch technique can be adopted as long as the site where the needle punctures the skin remains sterile. If a premade pack is used, only minimal common equipment shared by the group should be included within the pack, and sterile dish/tray/galley pots should not be included. An ultrasound transducer cover is not required for the prescan.

The practice parameters with strong consensus for aseptic techniques were similar for epidural, traditional nerve block catheter, and catheter-over-needle catheter placement. These parameters were cleaning hands with alcohol scrub only and wearing sterile gloves, scrub hats, and face masks. Nevertheless, the consensus varied regarding reusable attire for these procedures. For setup, the procedure site should be cleaned with an antimicrobial preparation and the sterile field should be draped. For catheter-over-needle catheter placement, an antimicrobial skin preparation only needs to be applied once. Similar to spinal single injection, only minimal equipment should be used in the premade pack, which can be used as the sterile workspace. Full sleeve cover for both the ultrasound transducer and its cable during real-time needling is required for all three procedures, unless it is a prescan, for which no transducer cover is required. For an epidural, a plastic adhesive ultrasound transducer cover (e.g., Tegaderm$^{TM}$ [3M$^{TM}$, Saint Paul, MN, USA]) is not sufficient if real-time needling is performed.

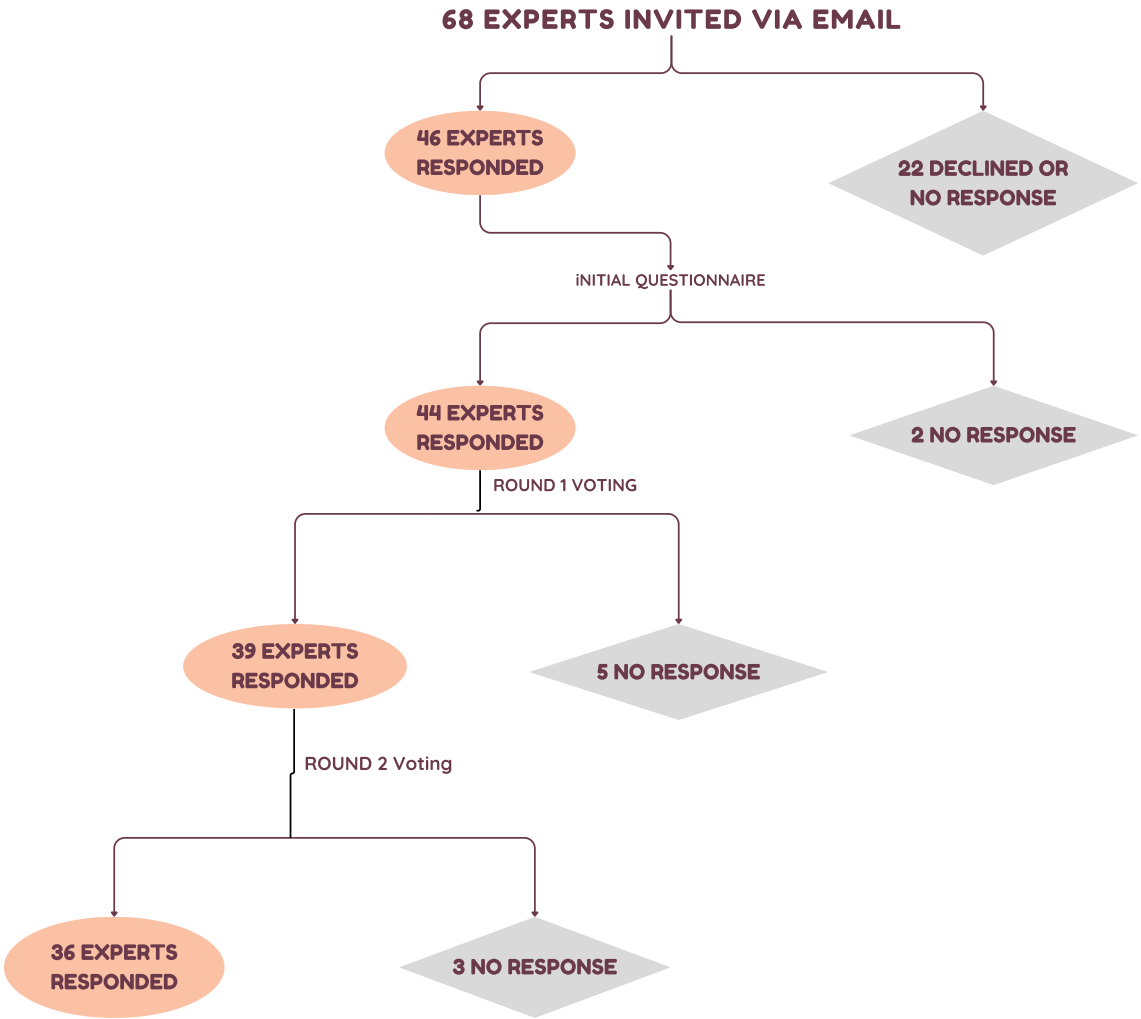


**Figure** Structure of the Delphi consensus process and number of participating experts

## Discussion

This Delphi study summarizes expert consensus and serves as guidance for balancing resource stewardship in the clinical practice of RA while recognizing evidence-based infection-prevention practices. A total of 36 collaborators from various high-income countries and subspecialties provided strong consensus on 65 items that pertain to the clinical practice of aseptic techniques and procedure setup for RA and are relevant to environmentally sustainable practice. The process of each practice should be examined to ensure minimal resources are used to further mitigate the environmental impact of RA.

There was strong consensus that a sterile gown was unnecessary for either PNB single injections or spinal single injections, and a trend was obtained that this is also not required for catheter techniques, which is consistent with the evidence.[16] There was also strong consensus that minimal equipment should be included in the premade pack and the pre-existing packaging for equipment; for example, indwelling perineural catheter packaging can be used as a sterile workspace. Surprisingly, only weak consensus was obtained for using small plastic adhesive covering for the ultrasound transducer for single-injection PNBs and catheter-over-needle assembly with very short catheters. Another unexpected finding was a high degree of uncertainty among the experts regarding reusable *vs* disposable attires, despite existing life cycle analysis (LCA) data appraising the environmental impact,[16,17] showing the need to raise awareness of such data, which is less familiar to most anesthesiologists.

While cardinal infection prevention recommendations such as hand hygiene are rooted in evidence, several best-practice recommendations to reduce infectious complications in anesthesia practice are based on expert opinion or preclinical evidence.[7–11,18–21] This may be because infection rates have reduced considerably over recent decades,[22] e.g., the incidence of epidural abscess

postanesthesia is approximately 0.07–0.007% in nonobstetric patients,[23,24] and none was reported in an obstetric cohort of 2,320,950 individuals.[24] Further actions to mitigate infection may not yield a clinically significant benefit, and an infection rate of zero is unrealistic because of multifactorial etiologies. This is not to trivialize the detrimental outcomes of infection following either PNB or neuraxial block in particular. Nevertheless, there now is a conundrum related to the balance between the extent of infection control and the environmental impact of many components of our practice.[25]

Overall, there was consensus among our experts on the practice of conserving financial and environmental resources while maintaining excellent infection prevention. Hand-mediated transmission is well understood as the major contributing factor to health care-associated infections.[26,27] Alcohol-based hand rub between patients and activities has been advocated by the Hand Hygiene Liaison Group, which will limit the use of resources such as water, towels, and energy used to wash the towels.[26]

Another important item that reached strong consensus was the need for oxygen therapy to be titrated to an individualized target oxygen saturation.[28] Whenever RA provides adequate surgical anesthesia, deep sedation or general anesthesia is often not necessary if appropriate patient education and nonpharmacological strategies have been followed and if expectations have been managed.[29,30] Minimizing oversedation and hence the need for oxygen therapy should be considered in RA as the compression of medical oxygen from air to liquid is energy intensive.[31,32] Although a very small decrement to the overall use of oxygen in a hospital, this would further reduce carbon dioxide emission from RA without compromising patient care.

There were some notable inconsistencies in the consensus obtained in this study. The first was a variation in whether antiseptic solution should be applied once or twice. As part of the CLEAN (chlorhexidine alcohol *vs* povidone iodine alcohol, with and without skin scrubbing, for prevention of intravascular-catheter-related infection) study with central venous catheter insertion, the one-step procedure, where the skin was disinfected with antiseptic solution once[33] or with a single spray application of 0.5% chlorhexidine in alcohol,[34] did not show any difference compared with the two-step technique. Randomized controlled trials have shown that a chlorhexidine 0.5% skin preparation is more effective than povidone iodine at preventing surgical site infection, colonization of catheters, and infection associated with vascular access.[35–38] Nevertheless, there currently exists a lack of robust randomized controlled trials on PNBs or neuraxial blocks, and, in some countries, there is an uncertainty about using 2% chlorhexidine with alcohol *vs* 0.5% chlorhexidine alcohol because of concerns regarding the neurotoxic potential of higher concentrations of chlorhexidine.[39]

The second area of inconsistent consensus was the use of reusable operating room attires and drapes. The major comment referenced the lack of LCA data. Nevertheless, several studies that have assessed the environmental impact found that disposable wear has a pronouncedly greater carbon footprint than reusable attire.[16,17] These results show that LCA data relevant to products used among anesthesiologists requires additional attention and amplification to achieve greater practice-altering penetration.

The third area of inconsistent consensus was the use of an ultrasound transducer cover. This included single-injection PNBs and neuraxial spinals, as well as PNB and epidural catheter insertion. This is likely related to manufacturers' recommendations and a lack of robust evidence for guidance. The Spaulding classification categorizes how the risk of infection drives recommendations relevant to levels of cleaning or reprocessing of ultrasound transducers. Nevertheless, international variation in guidelines for ultrasound transducer disinfection persists because of varying thresholds in categorization. Some categorize the ultrasound transducer as being "critical," requiring sterile transducer cover use for every real-time ultrasound-guided procedure, followed by high-level disinfection, even though the evidence that supports the recommendation is not robust.[9,10] Further, some literature on infection relate to the ultrasound gel rather than the transducer cover,[40,41] or ultrasound uses unrelated to RA, e.g., the endocavity transducer.[42] Other literature is specifically related to immunocompromised populations and does not apply to most RA patients.[43] It is important to recognize that the routine use of bacterial colonization or contamination as a surrogate for clinical infection can be misleading.[44] There is strong consensus among experts that bacterial colonization is not the same as infection; therefore, guidelines based on the extrapolation of bacterial colonization should be interpreted with caution as the current overprotective measures may lead to overuse of protective equipment or sterilization processes.[9,10]

Many infection prevention practices are based on low-level evidence, and recommendations vary internationally. Infectious complications are uncommon in RA, and hence, the quality of evidence for such recommendations may be limited to case reports/series, or expert opinion. Once guidelines are published, they may inadvertently acquire the status of an absolute standard of practice, despite the often limited level of evidence for the recommendations within. Conservative recommendations

**Table** Strong and weak consensus on environmentally responsible practice in regional anesthesia, reconciling infection prevention and resource stewardship

| | Strong consensus | Weak consensus |
|---|---|---|
| **Operator asepsis** | | |
| Alcohol scrub only for hand preparation (assuming hands are socially clean) | • Spinal single injection<br>• Epidural<br>• PNB single injection<br>• Traditional NB catheter<br>• Catheter-over-needle NB catheter | |
| Sterile gloves are required | • Spinal single injection<br>• Epidural<br>• Traditional NB catheter<br>• Catheter-over-needle NB catheter | • PNB single injection |
| Scrub hat is required | • Spinal single injection<br>• Epidural<br>• Traditional NB catheter<br>• Catheter-over-needle NB catheter | |
| Scrub hat should be reusable | • Epidural<br>• Traditional NB catheter | • Spinal single injection<br>• PNB single injection<br>• Catheter-over-needle NB catheter |
| Face mask is required | • Spinal single injection<br>• Epidural<br>• Traditional NB catheter<br>• Catheter-over-needle NB catheter | • PNB single injection |
| Sterile gown NOT required | • Spinal single injection<br>• PNB single injection | • Traditional NB catheter<br>• Catheter-over-needle NB catheter |
| If sterile gown is required, it should be reusable | • Traditional NB catheter | • Spinal single injection<br>• Epidural<br>• PNB single injection<br>• Catheter-over-needle NB catheter |
| **Setup** | | |
| Nerve block site on patient should be cleaned with antimicrobial skin preparation | • Spinal single injection<br>• Epidural<br>• PNB single injection<br>• Traditional NB catheter<br>• Catheter-over-needle NB catheter | |
| Antimicrobial skin preparation to be applied to skin once rather than twice with applicator | • Catheter-over-needle NB catheter | • Spinal single injection<br>• Epidural<br>• PNB single injection<br>• Traditional NB catheter |
| Sterile drape NOT required | • PNB single injection | |
| If premade pack used, only minimal common equipment shared by the group should be included within the pack | • Spinal single injection<br>• Epidural<br>• Single injection PNB<br>• Traditional NB catheter<br>• Catheter-over-needle NB catheter | |
| Premade pack can be used as sterile workspace | • Epidural<br>• Traditional NB catheter<br>• Catheter-over-needle NB catheter | |
| Use sterile dish/tray/galley pots within your set up | | • Spinal single injection |

**Table** continued

| | Strong consensus | Weak consensus |
|---|---|---|
| If sterile dish/tray/galley pots are used, should these items be reusable? | | • Spinal single injection<br>• PNB single injection |
| Do NOT use sterile dish/tray/galley pots within your set up | • Traditional NB catheter | |
| Aseptic nontouch technique can be adopted onto sterile site (i.e., as long as the needle puncturing the skin stays sterile) | • PNB single injection | |
| If only for pre-scan prior to procedure, no ultrasound probe cover is necessary | • Spinal single injection<br>• Epidural<br>• PNB single injection<br>• Traditional NB catheter<br>• Catheter-over-needle NB catheter | |
| Plastic adhesive (e.g., Tegaderm$^{TM}$) CAN be used to cover ultrasound probe while needling | | • PNB single injection |
| Plastic adhesive (e.g., Tegaderm$^{TM}$) CANNOT be used to cover ultrasound probe while needling | • Epidural | • Spinal single injection<br>• Traditional NB catheter<br>• Catheter-over-needle NB catheter |
| Full sleeve cover for ultrasound probe should be used to cover both ultrasound probe and its cable while needling | • Spinal single injection<br>• Epidural<br>• Traditional NB catheter<br>• Catheter-over-needle NB catheter | |
| Full sleeve cover for ultrasound probe should NOT be used to cover both ultrasound probe and its cable while needling | | • PNB single injection |
| Antimicrobial dressing is NOT required for securing the catheter | | • Traditional NB catheter<br>• Catheter-over-needle NB catheter |
| **Generic statements related to RA and sustainable practice** | | |
| | Anesthesiologists with knowledge in environmental sustainability should be part of the hospital/institutional procurement team | |
| | There should be increased education for surgeons on the environmental and clinical benefits of RA | |
| | There should be increased education to residents/trainees regarding clinical and environmental benefits of RA | |
| | Bacterial colonization is NOT the same as infection | |
| | Reusable nerve block infusion pumps should be used for home/ambulatory regional anesthetic if possible | |
| | Inhouse laundry services should be preserved for processing reusable attire wherever possible | |
| | Oxygen therapy requirement should be titrated to an individualized target oxygen saturation | |
| | Sedation level should be reduced if oxygen therapy is $> 5$ L·min$^{-1}$ or if a nonrebreather oxygen mask is required rather than nasal prongs or simple oxygen mask | |
| | Prefilled drug syringes should be made available | |
| | Nonpharmacological means of relaxation such as music and patient education should replace sedation with medication in suitable circumstances | |
| | Specific drug disposal systems should be used e.g., pharmaceutical waste bags/bins | |

**Table** continued

| | Strong consensus | Weak consensus |
|---|---|---|
| | After achieving an effective coverage for surgical anesthesia with regional techniques, general anesthetic should not be necessary and patients' expectations should be aligned as such, if possible | |
| | | Warm blanket should be used in preference to electric forced air warmer for patient comfort during RA |

Definition of strong consensus $\geq$ 75% agreement

Definition of weak consensus 50–74% agreement

NB = nerve block; PNB = peripheral nerve block; RA = regional anesthesia

may overemphasize certain aspects of infection prevention, or extrapolate them from other practices (e.g., vascular access or the use of ultrasound probes on nonintact skin)[45,46] without considering their efficacy or environmental impact. Given the scale of anesthetic practice, even minor practice changes may contribute to a cumulative impact on the ever-increasing environmental harms of health care in the current context of climate crisis.

Limitations of this Delphi consensus study are mostly related to the nature of our Delphi methodology. Given the motivation underpinning this work (i.e., concerns about how to reconcile infection control and environmental stewardship), respondents may have had preconceptions about environmentally sustainable practice. The purpose of the broad-based initial questionnaire was to avoid biased opinions from the steering committee members, who are passionate about environmental sustainability practices. Other subgroup populations such as immunocompromised individuals; those at elevated risk of infection; or pediatric, cardiac surgical, or emergency medicine populations were not included in this Delphi consensus study; therefore, the results cannot be extrapolated to these populations and clinical judgement is warranted. In addition, other aspects of RA were not included in our study, such as choice of medications and administration techniques for RA and sedation; electricity to drive the drug delivery systems or the ultrasound machines; and other methods used to make the patient physically comfortable such as pillows. Lastly, the participants of this Delphi consensus study were largely from a small number of high-resourced jurisdictions, which corresponds to the bibliometric analysis of the world's top RA publication-producing countries.[47] The findings may be less applicable to those practicing in low-resourced areas or, indeed, high-resourced countries where health care systems differ substantially from those represented by the study collaborators. Global inclusion was limited because of various factors including no responses from invited experts, the strict response timeline, and seeking inputs on techniques that may not be common practice in low-resource health care systems, e.g., different types of nerve block catheter techniques. Nonetheless, our study serves as a guide for planning future studies, including experts in low/middle-resource countries. Our response rate was 78% and might have been higher had the experts been given a longer-period of response time, which could have affected the final consensus. While our Delphi consensus study aims to provide general guidance on RA practice parameters, there are situations where clinical judgement takes precedence, i.e., the level of precautions should correspond to the incidence and severity of infectious complications. It should also be recognized that our study highlights areas where robust evidence is required. Environmental responsibility in terms of resource consciousness should be an ongoing process in RA practice as further evidence emerges to mitigate the environmental impact.

In conclusion, we have defined a Delphi-based consensus on environmentally responsible practice of RA for both single-injection and indwelling catheter techniques, although strong consensus was not reached for all practice parameters. While more robust evidence is being generated, clinicians can use this as a guide to their practice with environmental sustainability in mind. The results also identified areas of future research focus.

**Author contributions** The steering committee (*Vivian H. Y. Ip*, *Rakesh V. Sondekoppam*, *Clifford L. Shelton*, *Forbes McGain*, *and Danielle Eusuf*) were responsible for study concept, design, and conduct. All authors contributed to generating the questions for the survey for voting, and collecting the data. *Vivian H. Y. Ip* and *Rakesh V. Sondekoppam* performed data analysis. *Vivian H. Y. Ip* contributed to manuscript preparation and *Clifford L. Shelton*, *Forbes McGain*, *Rakesh V. Sondekoppam*, *Danielle Eusuf*, *Deirdre Kelleher*, *Galaxy Li*, *Alan J. R. Macfarlane*, *Julien Raft*, *Kristopher M. Schroeder*, and *Thomas Volk* contributed to editing. All authors reviewed the manuscript for important intellectual content.

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