Simulation-based ultrasound-guided regional anesthesia education: a national survey of Canadian anesthesiology residency training programs

Formation en anesthésie régionale guidée par simulation : une enquête nationale sur les programmes canadiens de résidence en anesthésiologie

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Abstract

Purpose *Simulation-based education in ultrasound-guided regional anesthesia (UGRA) improves knowledge, skills, and patient outcomes. Nevertheless, it is not known how simulation-based UGRA education is used across Canada. We aimed to characterize the current use of simulation-based UGRA education in Canadian anesthesiology residency training programs.*

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Methods *We developed and distributed a structured national survey to simulation leads of all 17 Canadian anesthesiology residency training programs. The survey inquired about program demographics, simulation modalities, facilitators and barriers to simulation use, use for assessment, and beliefs around simulation-based UGRA education. We gathered data from August to November 2023 and summarized our findings descriptively.*

Results *Fifteen programs (88%) responded to our survey. Eight programs (53%) used UGRA simulation for technical training and nine programs (60%) for nontechnical training. The most common simulators used were live model scanning (13 programs, 87%) and gel phantom models (7 programs, 47%). Five programs (33%) mandated simulation-based UGRA in their curriculum. We found that deliberate practice and improved patient safety were most valued in simulation training while lack of funding and faculty availability were the most common barriers to implementation. Most respondents agreed that formative simulation-based education would improve trainee skills and called for greater standardization. Nevertheless, there were mixed responses regarding summative UGRA simulation and the need for simulation proficiency before clinical practice.*

Conclusions *Our findings show significant variations in simulation implementation and views on UGRA simulation-based education among Canadian anesthesiology residency training programs. Future studies should explore avenues to overcome barriers and improve knowledge translation in UGRA.*

Résumé

Objectif *La formation basée sur la simulation en anesthésie régionale échoguidée améliore les connaissances, les compétences et les issues pour les patient·es. Néanmoins, on ne sait pas comment la formation en AR échoguidée basée sur la simulation est utilisée au Canada. Nous avons cherché à caractériser l'utilisation actuelle de l'enseignement de l'AR échoguidée basée sur la simulation dans les programmes canadiens de résidence en anesthésiologie.*

Méthode *Nous avons élaboré et distribué un sondage national structuré aux responsables de la simulation des 17 programmes canadiens de résidence en anesthésiologie. L'enquête portait sur les données démographiques du programme, les modalités de simulation, les facilitateurs et les obstacles à l'utilisation de la simulation, son utilisation pour l'évaluation, et les croyances concernant l'éducation en AR échoguidée basée sur la simulation. Nous avons recueilli des données d'août à novembre 2023 et résumé nos résultats de manière descriptive.*

Résultats *Quinze programmes (88 %) ont répondu à notre sondage. Huit programmes (53 %) utilisent la simulation en AR échoguidée pour la formation technique et neuf programmes (60 %) pour la formation non technique. Les simulateurs les plus couramment utilisés étaient le balayage sur modèles vivants (13 programmes, 87 %) et les modèles de fantômes en gel (7 programmes, 47 %). Cinq programmes (33 %) ont rendu obligatoire l'AR échoguidée basée sur la simulation dans leur programme. Nous avons constaté que la pratique délibérée et l'amélioration de la sécurité des patient·es étaient les plus appréciées dans la formation par simulation, tandis que le manque de financement et la disponibilité du corps professoral étaient les obstacles les plus courants à la mise en œuvre. La plupart des répondant·es ont convenu que l'éducation formative basée sur la simulation améliorerait les compétences des stagiaires et ont appelé à une plus grande standardisation. Néanmoins, les réponses étaient mitigées concernant la simulation sommative en AR échoguidée et la nécessité d'une maîtrise de la simulation avant la pratique clinique.*

Conclusion *Nos résultats montrent des variations significatives dans la mise en œuvre de la simulation et les points de vue sur l'éducation basée sur la simulation en AR échoguidée parmi les programmes canadiens de résidence en anesthésiologie. Les études futures devraient explorer les moyens de surmonter les obstacles et d'améliorer l'application des connaissances à l'anesthésie régionale échoguidée.*

Keywords regional anesthesia · SBME · simulation · UGRA · ultrasound-guided regional anesthesia

Regional anesthesia is a core skill used by anesthesiologists to provide pain relief for various surgical procedures with several advantages, including reduced morbidity and mortality, shorter hospital stays, reduced health care costs, and increased patient satisfaction.[1,2] Ultrasound-guided regional anesthesia (UGRA) is commonly taught through a combination of didactic lectures, observation of live procedures, and hands-on experience under the supervision of an experienced practitioner.[3,4] The apprenticeship model consisting of observation of a skill followed by learning through clinical practice is less acceptable because of concerns regarding patient safety and the transition to competency-based medical education (CBME).[2,5] Additionally, there may be significant variability in the quality of instruction provided by different mentors, and there is no guarantee that the trainee will have acquired the necessary knowledge, skills, and attitudes in UGRA.[2,4]

Simulation-based medical education (SBME) enhances medical training by offering a controlled learning environment for deliberate practice and feedback.[3,4] In regional anesthesia, SBME consists of technical and nontechnical skills. Technical skills mostly relate to hands-on practice using simulation models like gel phantoms and task trainers for clinical practice.[6] Nontechnical skills can include management of local anesthetic systemic toxicity, disclosure of an adverse event, and obtaining patient consent before a procedure. A systematic review found that UGRA simulation can improve acquisition of skills and knowledge, clinical performance, and patient outcomes.[6] Therefore, the incorporation of SBME may be a useful tool to complement existing regional anesthesia curricula and reduce gaps in clinical training within the context of CBME.

There is currently a lack of knowledge regarding how SBME is used for formative and summative UGRA training in Canadian anesthesiology residency training programs. To address this knowledge gap, we conducted a national survey to gather information about the use of UGRA simulation. This study aims to provide a comprehensive overview of UGRA simulation programs across Canada and identify barriers and facilitators to their implementation.

Materials and methods

Survey development

We obtained research ethics board approval for this study from the University of Ottawa in July of 2023 (University of Ottawa Research Ethics Board, Ottawa, ON, Canada;

IRB: H-06-23-9320). For this cross-sectional national survey study, the initial questions were developed based on prior surveys related to SBME and UGRA education identified through MEDLINE, PubMed®, and Google Scholar.[7–15] The questions were then compiled based on themes and topics from these articles and adapted to gaps within the Canadian context. These gaps were addressed by the study investigators, who collectively have experience in SBME, UGRA, and survey methodology. The final set of 16-items was used to create a digital questionnaire with Google Forms (Alphabet Inc., Mountainview, CA, USA). We also included an option for respondents to provide written comments regarding any other thoughts they may have on the use of simulation in anesthesiology.

The questions aimed to gather information on program demographics, simulation modalities, access to and exposure of residents to simulations, the number of hours dedicated to simulations, and whether simulations are used for assessment in UGRA (Electronic Supplementary Material eAppendix). Additionally, the survey sought to identify the tools used for UGRA assessment in the simulated setting and the frequency of evaluation. Five survey questions included a free text field to collect data not covered by the available response options. The survey was piloted once with two anesthesiology faculty members with expertise in SBME and regional anesthesia at the University of Ottawa, and further refined based on the feedback. The final survey, produced in English and French, included four sections and 24 questions and was approved by all study investigators prior to dissemination.

Survey distribution

The survey was distributed via e-mail through the Canadian National Anesthesiology Simulation Curriculum (CanNASC) network to the simulation leads of all 17 Royal College of Physicians and Surgeons of Canada-accredited anesthesiology residency training programs. The simulation leads completed the survey themselves, or delegated completion to a regional anesthesia educational lead at their institution. We allowed only one response per institution by a designated lead in simulation, regional anesthesia, or both in collaboration. The names of the institutions were monitored to prevent duplicate responses. Our data were collected between 1 August and 30 November 2023, whereby an electronic informed consent form and hyperlinks to the online forms were sent to the participants. Reminder e-mails were sent at two weeks and one month following the initial invitation. No incentives were provided to participants.

Statistical analysis

We deidentified and analyzed the survey responses in Microsoft® Excel (Microsoft Corporation, Redmond, WA, USA). We reported demographic data, UGRA teaching methods, UGRA simulation characteristics, and facilitators/barriers to UGRA as frequencies and percentages. For the statement question, we categorized the responses as "strongly disagree," "disagree," "neutral," "agree," or "strongly agree." All responses to open-ended questions were independently analyzed by two investigators using thematic content analysis. Consensus was reached on parsimonious themes through discussion. No sample size estimation/calculation was performed beyond our intent to invite all Canadian anesthesiology residency training programs to respond. Our study did not have a discrete testable hypothesis because of the limited previous research on UGRA simulation use in Canada. Our aim was to gauge the landscape of simulation-based UGRA education nationally. We reported our findings in accordance with the Consensus-Based Checklist for Reporting of Survey Studies (CROSS).[16]

Results

Out of all 17 academic institutions we targeted in this national survey, 15 (88%) returned a completed questionnaire. There were no duplicate responses from the same institution and no missing data from any of the responses. Most respondents were clinician simulation instructors, and most programs had more than 20 residents and offered fellowship training in regional anesthesia (Table 1).

Ultrasound-guided regional anesthesia teaching methods

Our survey revealed a diverse range of UGRA educational methods employed across Canadian anesthesiology residency training programs (Table 2). The most common educational methods were didactic sessions and simulations, while self-directed learning and social media platforms were less common methods for teaching UGRA. We found that two out of 15 institutions (13%) used one method to teach UGRA, two institutions (13%) used two teaching methods, six institutions (40%) used three teaching methods, three institutions (20%) used four teaching methods, one institution (7%) used five teaching methods, and one institution (7%) used six teaching methods.

Table 1 Characteristics of respondents and participating Canadian anesthesiology residency training programs

Characteristic	Residency programs N = 15
Role of respondent, *n*/total *N* (%)	
Clinician simulation instructor	10/15 (67%)
Regional anesthesia education lead	4/15 (26%)
Residency program director	1/15 (7%)
Program size, *n*/total *N* (%)	
5–9 residents	1/15 (7%)
10–14 residents	1/15 (7%)
15–20 residents	1/15 (7%)
More than 20 residents	12/15 (80%)
Regional anesthesia fellowship offered, *n*/total *N* (%)	
No	6/15 (40%)
Yes	9/15 (60%)

Table 2 Ultrasound-guided regional anesthesia teaching methods used by Canadian anesthesiology residency training programs

UGRA teaching method*	Residency programs N = 15
Didactic	13/15 (87%)
Simulations	13/15 (87%)
Direct shadowing	11/15 (73%)
Group learning	11/15 (73%)
Self-learning modules	4/15 (27%)
Social media	1/15 (7%)

All numbers are *n*/total *N* (%) of programs

*Respondents were allowed to choose more than one option

UGRA = ultrasound-guided regional anesthesia

Simulation use

Out of 15 programs, 8 (53%) reported using simulations for UGRA procedural skills, while nine (60%) used simulations for nontechnical training focusing on crisis resource management skills. None of the programs use simulations for evaluating residents' UGRA performance. The simulation types employed most often were live model scanning (13 programs, 87%) and gel phantom models (seven programs, 47%). Only five programs (33%) mandated simulation training as part of their curriculum for residents (Table 3).

Facilitators and barriers to simulation use

The leading reported facilitators of simulation use were the opportunity for deliberate practice, improved patient safety, and interest from residents. Interest from faculty was the least endorsed facilitator to simulation use in UGRA, selected by only two (13%) programs. Lack of funding, faculty availability, and simulator availability were the major reported impediments to simulation use (Table 4). Specific concerns noted by some respondents in the open text section included the poor state of UGRA simulators at certain institutions.

Statement agreement on simulation use and utility

Respondents were evenly split on whether simulation-based education for training should be increased, with only a third agreeing that UGRA proficiency on simulators should be necessary before clinical practice and that UGRA simulators were vital for skill assessment. Sixty percent believed regular simulation use would maintain and improve UGRA skills, though only 34% felt the time allotted for simulation-based education was sufficient. About half of respondents endorsed the need to standardize UGRA assessment simulations across Canada, and 60% supported the national standardization of UGRA training simulations (Figure).

Open-ended question

In the responses to the open-ended question regarding the use of simulations in anesthesiology, a range of themes were identified. Some respondents highlighted the pressing need for higher fidelity simulators in UGRA, pointing towards a demand for more advanced and realistic simulation tools. Others stated that the complexity of UGRA skills underlines the challenges in adequately covering all aspects of UGRA training through simulation use alone. Furthermore, there was a consensus that, while simulations are unlikely to replace the entire spectrum of training, they serve as valuable supplementary tools to current training methods. Additionally, simulations were noted to be especially beneficial at the onset of residency as this period is crucial for developing basic clinical skills, and simulations provide an effective platform for early-stage training.

Discussion

Despite evidence that simulation-based UGRA education improves knowledge, skills, behaviour, and patient outcomes, the results of our survey show large variability across Canada in the delivery and perceptions towards using SBME for teaching and assessing UGRA skills. We found that only half of Canadian anesthesiology residency training programs offered simulation-based education for

Table 3 Purpose, type, and availability of simulation use in ultrasound-guided regional anesthesia training among Canadian anesthesiology residency programs

UGRA simulation training*	Residency programs N = 15
Purpose of simulation, *n*/total *N* (%)	
Technical training	8/15 (53%)
Nontechnical training	9/15 (60%)
Assessment	0/15 (0%)
Simulation type, *n*/total *N* (%)	
Live model scanning	13/15 (87%)
Gel phantom models	7/15 (47%)
Screen-based educational modules	3/15 (20%)
Part task trainers	3/15 (20%)
Cadaver models	3/15 (20%)
Meat-phantom models	2/15 (13%)
High-fidelity mannequins	2/15 (13%)
Augmented or virtual reality	0/15 (0%)
Simulation availability, *n*/total *N* (%)	
Mandated by curriculum	5/15 (33%)
Self-guided access	3/15 (20%)
Resident request	3/15 (20%)
Not sure/not applicable	7/15 (47%)

*Respondents were allowed to choose more than one option

UGRA = ultrasound-guided regional anesthesia

UGRA technical training while slightly more than half of the programs offer nontechnical training. The greater prevalence of nontechnical training may be attributed to the variability of clinical events, such as local systemic toxicity and conflict management. This ensures that trainees receive exposure to these topics, regardless of their frequency in clinical practice. Most programs continued to use didactic sessions and direct shadowing, which highlights the ongoing reliance on traditional, passive learning approaches. Active involvement in training can be more effective than passive learning methods.[17] Meanwhile, simulations have been found to foster better clinical learning and superior skill demonstration compared with didactic teaching in an ultrasound curriculum of anesthesiology residents.[18]

Among the programs that used UGRA simulation, the frequent use of live-model scanning and gel phantom models, followed by the less frequent use of other modalities like screen-based modules, suggests a preference for hands-on, low-fidelity simulation experiences. This preference might be driven by the perceived effectiveness and availability of these modalities in mimicking real-life scenarios without excessive costs to the program. The low prevalence of

more realistic simulator modalities (meat models, cadavers, part-task trainers, and high-fidelity mannequins) likely reflects challenges in the cost, storage, maintenance, and procurement of these models. Moreover, existing literature does not consistently support that high-fidelity simulations enhance learning or behavioural outcomes compared with low-fidelity simulations.[19,20]

Canadian programs lag behind their USA counterparts where 80% of anesthesiology residency training programs incorporate simulations in UGRA education.[9] In contrast, the low use of simulations for UGRA assessment in Canada is similar to USA anesthesiology residency training programs. This may reflect a broader challenge with integrating simulation-based assessment into training curricula, possibly because of resource constraints or the need for more developed or validated assessment methodologies. Numerous evaluative scales have been developed for the assessment of regional anesthesiology skills, yet their implementation in clinical practice remains notably infrequent, especially in simulated settings.[21,22] This may reflect a lack of awareness regarding these validated rating scales among the programs.

The identification of deliberate practice and improved patient safety as leading facilitators for simulation use underscores the perceived value of SBME in enhancing clinical skills and ensuring patient safety. One survey found that anesthesiology residents report increased confidence in regional anesthesia procedures with sufficient training and exposure.[23] Yet, the inherent stress of real patient interactions and the variability in procedural opportunities because of patient diversity can present limitations. Furthermore, there are ethical concerns regarding learning through clinical practice alone, especially in the initial stages of residency training.[24] The reported barriers, mainly lack of funding, faculty and simulator availability, followed by lack of space and interest by faculty are in line with those reported by other countries and programs.[7,9,25] Existing resources may be optimized by sharing resources, content, and expertise through future collaborative educational initiatives.

We found that most respondents favoured standardizing UGRA training and assessment simulations nationally; however, approximately a third were unsure (neutral). This may reflect the logistical challenges regarding implementing a standardized program across diverse institutions, differences in available resources, and distinct educational philosophies. The divided opinions on whether the current time allocation for UGRA simulations is sufficient mirror these concerns.

This study has several limitations. First, only one representative reported on simulation-based UGRA training at each institution. Although efforts were made to minimize this limitation by identifying the conversant

Table 4 Facilitators and barriers to simulation use in ultrasound-guided regional anesthesia

Facilitators and barriers*	Residency programs N = 15
Facilitators of simulation use, *n*/total *N* (%)	
Deliberate practice	10/15 (67%)
Improved patient safety	8/15 (53%)
Interest from residents	7/15 (47%)
Availability of models	5/15 (33%)
Self-guided practice	5/15 (33%)
Evaluate learners outside of clinic	4/15 (27%)
Useful for educational research	3/15 (20%)
Interest from faculty	2/15 (13%)
Barriers to simulation use, *n*/total *N* (%)	
Lack of funding	9/15 (60%)
Lack of faculty availability	7/15 (47%)
Lack of simulator availability	6/15 (40%)
Lack of space availability	4/15 (27%)
Lack of faculty interest	3/15 (20%)
Lack of protected time for residents	3/15 (20%)
Lack of faculty training	2/15 (13%)
Lack of resident interest	1/15 (13%)
Other: Poor state of UGRA simulators	1/15 (13%)

*Respondents were allowed to choose more than one option

UGRA = ultrasound-guided regional anesthesia

experts via the CanNASC network, we did not capture data to indicate if further clarification was obtained or if the task was bestowed upon another expert. It is also possible that the representatives were unaware of some offerings in their programs, especially considering the ever-changing curriculum and the involvement of many faculty members in its design. Furthermore, the opinions on the use and utility of UGRA training do not necessarily reflect the opinions of entire programs or peers of the survey participants. Nevertheless, given that these representatives are leaders in either simulation or regional anesthesia, they are expected to be well-acquainted with the training standards at their institutions. Second, the survey's cross-sectional design inherently limits the ability to draw causal inferences and may not fully represent temporal changes in UGRA training practices. While the study achieved a high response rate (88%), the generalizability of our findings to the two programs that did not respond are uncertain. The study primarily used survey-based data, which carries the risks of response and selection biases. Third, although we provided several options for respondents to select regarding facilitators and barriers to UGRA simulation, and allowed for open-text replies, a qualitative research design (e.g., focus groups, in-depth interviews) may identify additional issues that could not be identified by our survey. Lastly, our study did not capture institutional resources, faculty expertise, and regional anesthesia curriculum
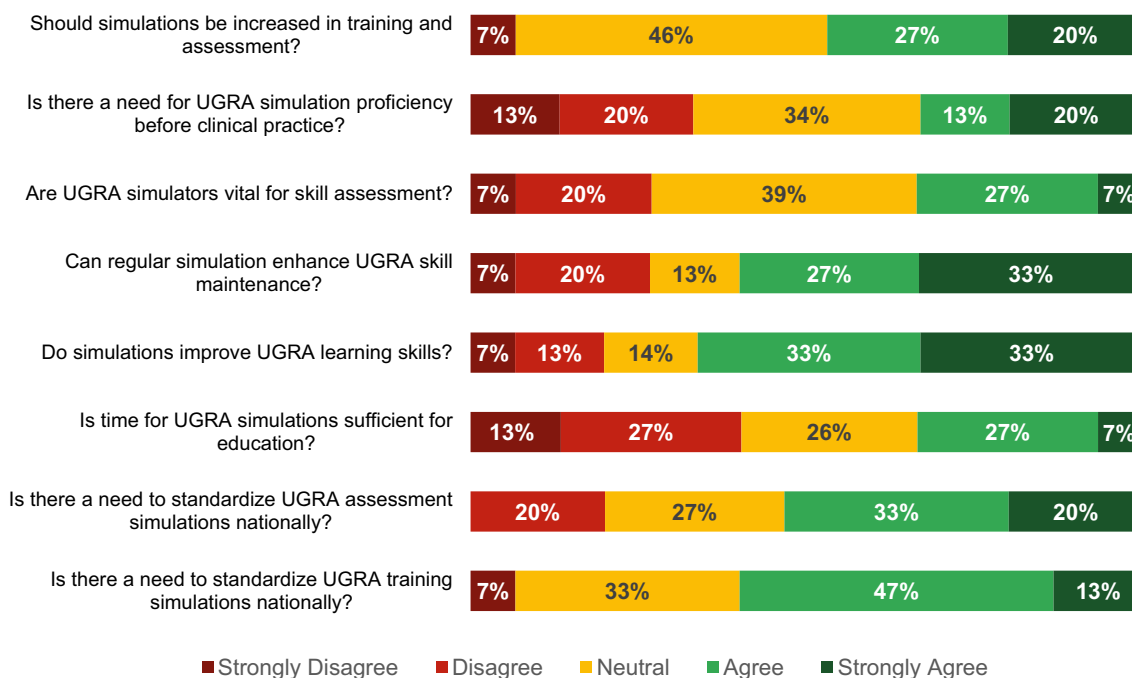

Figure Levels of agreement among respondents from Canadian anesthesiology residency programs regarding the utility of simulation-based ultrasound-guided regional anesthesia training. Each bar displays the percentage of responses to the corresponding question on its left.

UGRA = ultrasound-guided regional anesthesia

differences, all of which could influence the implementation and perceptions of simulation-based UGRA education.

Conclusion

Our national survey shows considerable variability regarding the implementation, type, and frequency of simulation use in UGRA training across Canadian anesthesiology residency training programs. The impact of these differences on clinical competencies and patients' safety is uncertain and is an important topic for future research. Future studies should integrate several key initiatives including creating a more structured framework for UGRA simulation delivery and enhancing guidance on UGRA and CBME assessments. Additionally, research should focus on understanding simulation training barriers through stakeholder feedback, examining learning curves, success rates, and patient outcomes in UGRA, and conducting a wider survey involving residents for deeper insights into UGRA procedures' comfort levels and national perspectives on simulation training. Gathering more evidence on the cost-benefit of simulation education in UGRA training will further inform its role in the training of Canadian anesthesia residents.

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