GE HealthCare

cNerve

AI to assist in ultrasound-guided nerve blocks

Delvaux Bernard, MD. Anesthesiologist, Private Hospital Claude Galien
Doron Shaked, DSc, Director Data & Analytics, GE HealthCare
Adi Pinhas Benzekry, MD. Clinical Insight Specialist, GE HealthCare

Background

Anesthesia's role in Enhanced Recovery After Surgery (ERAS) has grown in importance over the past few decades.[1] Drivers include better clinical outcomes such as shorter hospitalizations, rapid recovery, decreased complication rates, and lower postoperative pain.[2] The latter has gained increased focus recently due to the expansion of the opioid epidemic.[3]

This paper will provide a brief evolution of anesthetic techniques, from the early techniques through the addition of point-of-care ultrasound to guide regional anesthesia (UGRA). We will focus on the recent introduction of the cNerve tool to the Venue™ Family. This AI-based tool has been developed to aid clinicians in the identification of nerve anatomy and increase confidence in their clinical anesthesia practice. We will briefly describe the underlying technology and provide a summary of a retrospective usability trial conducted on the technology.

The role of anesthesia in ERAS and beyond

With its noticeable success in ERAS, the benefit of nerve blocks has expanded to multiple healthcare areas, including but not limited to obstetrics,[4] emergency medicine,[5] chronic pain management, cancer treatment pain management,[6] and physical therapy and recovery.[7]

An increased demand results in an increased need for training in these procedures.

The evolution of nerve block technique

The ever-evolving practice of nerve blocks was first practiced in the late 1800s with blind anatomical landmarks as the only guidance to correctly identify a nerve root.[8] Anatomical landmark with elicited paresthesia was the first kind of nerve block technique performed. To accomplish this technique, a needle is inserted until it is adjacent to, or directly in contact with, a nerve root. The patient then exhibits a paresthesia or "electrical-shock-like" response. Eliciting paresthesia is no longer recommended or considered standard of care because it is associated with discomfort, potential for nerve trauma, and persistent post block neuropathy.[9]

Complications related to needle-elicited paresthesia were lessened with the adoption of the nerve stimulator in the 1970s. A nerve stimulator localizes a nerve by using electrical stimulation to produce a motor response. Nerve stimulators are still commonly used in anesthesia practice today, but their accuracy is often questioned.[10]

The first two techniques have one thing in common: they are blind techniques. To increase the accuracy of locating nerve anatomy, the incorporation of ultrasound guidance was first introduced over 30 years ago. The ability to visualize needle position and nerve anatomy under ultrasound may provide the following benefits[11]:

01

Increases nerve block success rate.

02

Reduces the risk of intraneural and vascular damage.

03

Allows identification of nerve tissue from surrounding structures.

04

Reduces the time it takes to perform an effective block.

05

Provides a way to visualize the anesthetic is being injected into the correct location.

06

Often reduces the amount of anesthetic required to perform an effective block.

Overview of ultrasound uses in regional anesthesia

When visualized with an ultrasound, the perineurium, or nerve bundle, appears as a bright, hyperechoic circular or oval structure. Within the perineurium, the nerves appear as multiple smaller, darker, hypoechoic structures. Vascular structures are often adjacent or paired with nerve bundles and appear as black or anechoic circular structures. (Fig. 1)

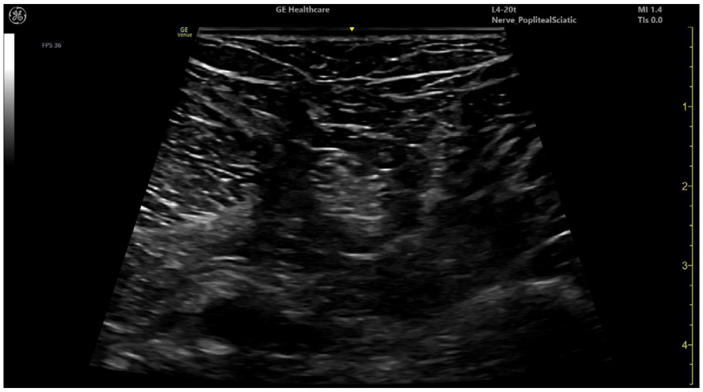


Fig. 1 Ultrasound image of the sciatic nerve in the popliteal space behind the knee.

Limitations of ultrasound guidance

Real-time ultrasound guidance for regional anesthesia is becoming a very common way to perform a nerve block. With the increasing prevalence of UGRA, there are also limitations that inhibit its adoption as standard of care. The limitations that hinder the growth of UGRA are:

01

Lack of expertise and ongoing professional training and proficiency.[12]

02

Ultrasound system availability, whether caused by lack of facility support for point-of-care ultrasound or inadequate budget.

03

Clinician's lack of familiarity with sono-anatomy.[13]

The Venue Family* solution: Our new auto tool, cNerve

To address the limitations that inhibit UGRA growth, various training models such as scan simulators, educational resources, and AI have emerged to support knowledge of sono-anatomy in anesthesia.[14]

The Venue Family provides point-of-care ultrasound systems that can be used for bedside exams. We saw the need to find a solution to provide real-time guidance and support to anesthesia providers. Our solution is an AI-based auto tool called cNerve. cNerve is a tool targeted at anesthesia and associated with nerve presets.

cNerve is designed to highlight nerve tissue structures in real time during the scouting stage of the ultrasound-guided nerve block procedure, namely prior to needling. During this stage, users familiarize themselves with the sono-anatomy of the patient and plan the needle approach. Challenges in this stage include identification and tracking of the nerve structures in the context of the relevant landmarks and the probe motion. These challenges are exacerbated by the high textural variability of the nerve structures and their similarity to textures of nearby tissue such as muscle, facia, and vessels. The ability to highlight the nerve tissue supports recognition of sono-anatomy and facilitates tracking the textures along the scouting procedure. cNerve enhances clinician confidence and provides real-time guidance during a nerve block procedure.[15]

Venue Fit™

Venue Go™

Venue™

How does cNerve work?

The cNerve tool is an innovative technology that utilizes deep learning segmentation techniques to automatically identify nerve structures in real-time ultrasound images. The tool has been designed specifically for Supraclavicular and Interscalene Brachial Plexus, Popliteal Sciatic, and Femoral blocks commonly used in pain management procedures.

Prior to the recent development of deep learning techniques, classical image processing and machine learning techniques were commonly used in medical imaging. These methods involved manually selecting and engineering features from images, which were time-consuming and prone to error. Modern deep learning techniques, on the other hand, automate this feature engineering process by learning patterns and relationships directly from large datasets, and enable to analyze complex medical images in ways that were previously impossible. This has led to significant advancements in the field of medical imaging, particularly in tasks such as segmentation and classification.

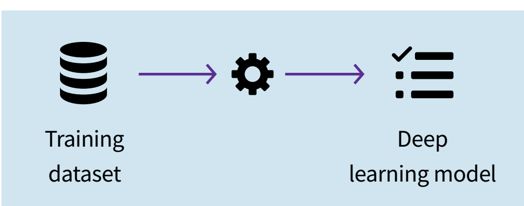
The deep learning algorithm used in the cNerve tool has been trained on hundreds of thousands of ultrasound images from hundreds of subjects. The training dataset was composed of representative distribution of various subgroups to ensure that the resulting models work for a wide range of patients, regardless of their age, BMI, or gender.

The deep learning algorithm used in the cNerve tool works by analyzing the ultrasound images and identifying specific patterns and features that are indicative of nerve structures. In addition, the algorithm has been supplemented with domain knowledge that incorporates expert input and clinical experience. This domain knowledge is used to guide the deep learning algorithm in identifying nerve structures, further improving the specificity and sensitivity of the nerve segmentation.

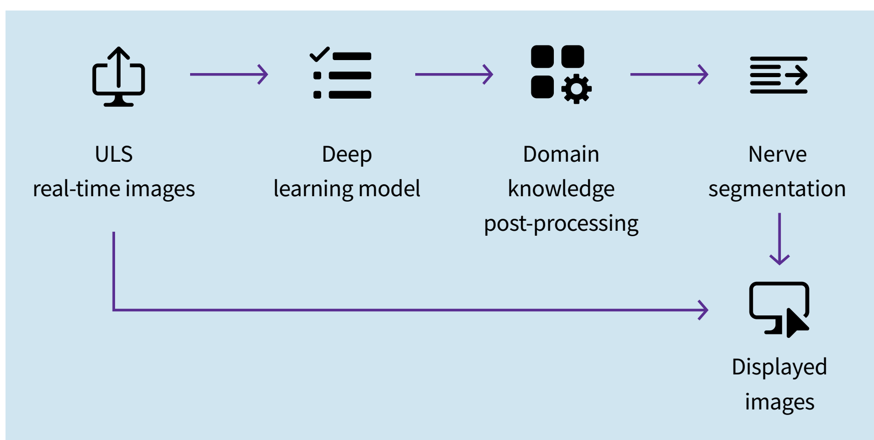
Once the ultrasound probe is placed on the patient's skin, the cNerve tool automatically analyzes the real-time ultrasound images and identifies the relevant nerve structures. The tool then highlights these structures on the ultrasound image, allowing practitioners to easily identify and target the nerves when administerin nerve blocks.

Overall, the cNerve tool represents a significant advancement in pain management technology. By using deep learning segmentation techniques to automatically identify nerve structures in real-time ultrasound images, practitioners can improve their accuracy and confidence when administering nerve blocks. This can ultimately lead to improved patient outcomes and greater patient satisfaction.

Deep learning training phase



Deployment phase



How to use cNerve on Venue

The cNerve auto tool is activated with one touch by selecting the anatomical region of interest the nerve block will be performed in. After the user selects the anatomy location and as soon as the scan begins, the algorithm detects the nerve tissue and places a yellow-colored overlay that highlights the nerve tissue in real time (Fig. 3-8). As the user scans, the yellow-highlighted area tracks and changes along with the anatomy.

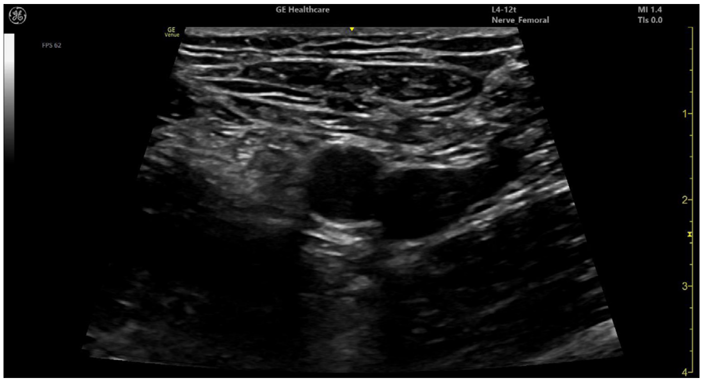


Fig.3 Femoral nerve block location.

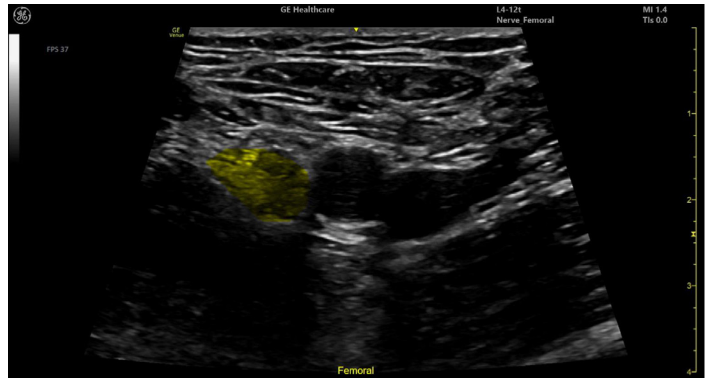


Fig.4 cNerve auto tool activated with one touch.

Fig.5 Brachial Plexus (supraclavicular) nerve block location.

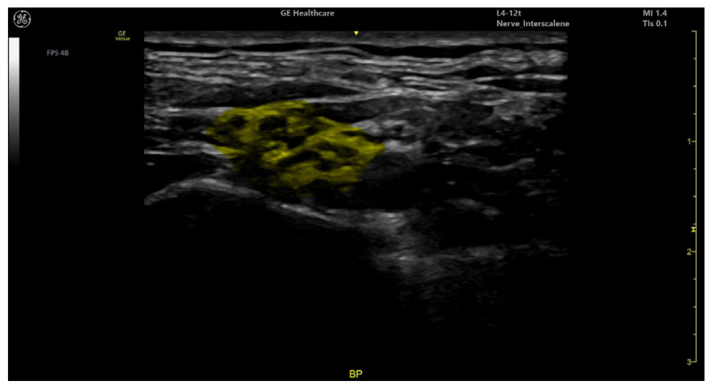


Fig.6 cNerve auto tool activated with one touch.

Fig.7 Popliteal Sciatic nerve block location.

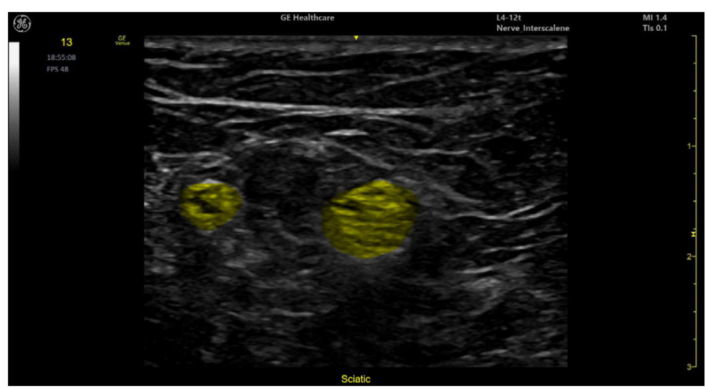


Fig.8 cNerve auto tool activated with one touch.

Strategy for cNerve's performance assessment and validation

Internal scanning collection was conducted after the model was trained. The data was collected in the US, Israel, and Japan and was acquired using the GE HealthCare Venue Family ultrasound scanners. For internal scanning locations where data was also collected for training purposes, we ensured volunteers were separate individuals. The data was used for the formal validation test and the reading study described on the following page.

cNerve reading study

A retrospective reading study was conducted to evaluate the benefit of cNerve tracking for the identification of individual nerve block regions prior to insertion of the needle.

Eight independent experts in regional anesthesia (from the U.S. and Israel, without any prior experience with cNerve) reviewed 24 ultrasound clips from three block regions: Popliteal Sciatic, Brachial Plexus (Interscalene and Supraclavicular), and Femoral. Unmodified ultrasound videos were presented side-by-side with cNerve-highlighted ultrasound videos.

Experts rated their overall confidence level using the cNerve, ascertained whether highlighting helped correctly identify specific anatomical structures, and provided opinion on whether they would prefer using cNerve during scouting to identify the injection site (Figure 9).

For each set of clips, please answer the following questions:

cNerve tool was able to track the nerve during scouting

1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree	NA Not applicable

Do you think the tool can increases physician's confidence in identifying the nerves?

1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree	NA Not applicable

In your opinion, will a physician prefer using the tool during nerve scouting to identify site injection?

[Y/N]

Fig.9 cNerve reading study questionnaire

One hundred and ninety-two assessments were performed. In 99% of cases (Mean score of 4.93 out of 5), clinicians agreed that cNerve was able to track the nerve during scouting. In 97% of cases (Mean score of 4.89 out of 5), clinicians agreed that using cNerve could increase confidence in identifying nerves. In 98% of cases (selected "Yes" from Y/N options), clinicians mentioned they would prefer to use cNerve during nerve scouting.[15]

Table 1 below summarizes the results.

Question	Mean Score	Rate Agree
cNerve was able to track	4.93	99% (answered 4 or 5)
cNerve would increase confidence	4.89	97% (answered 4 or 5)
Would prefer using cNerve during scouting		98% (answered Yes)

Table 1

This data demonstrates the clinical utility of the cNerve tool in aiding in the identification of anatomical structures in ultrasound-guided regional anesthesia.

Conclusion

UGRA, clinician training, and confidence need to go hand-in-hand to provide a safe patient experience and an effective way to manage patient pain before, during, and after procedures or treatments.

The Venue Family systems offer real-time assistance to accomplish nerve tissue recognition, which ultimately should increase procedural confidence. We have shown that cNerve increases user confidence and that users usually prefer using it during scouting. It has been shown that operator confidence correlates with the accuracy and success of EUS examinations.[16]

About GE HealthCare

GE HealthCare is a leading global medical technology, pharmaceutical diagnostics, and digital solutions innovator, dedicated to providing integrated solutions, services, and data analytics to make hospitals more efficient, clinicians more effective, therapies more precise, and patients healthier and happier. Serving patients and providers for more than 100 years, GE HealthCare is advancing personalized, connected, and compassionate care, while simplifying the patient's journey across the care pathway. Together our Imaging, Ultrasound, Patient Care Solutions, and Pharmaceutical Diagnostics businesses help improve patient care from prevention and screening, to diagnosis, treatment, therapy, and monitoring. We are an $18 billion business with 51,000 employees working to create a world where healthcare has no limits.

Follow us on Facebook, LinkedIn, Twitter, Instagram and Insights for the latest news, or visit our website gehealthcare.com for more information.

Resources

1. Ljungqvist, O., Scott, M., & Fearon, K. C. (2017). Enhanced recovery after surgery: a review. JAMA surgery, 152(3), 292-298.
2. Nelson, G., Kiyang, L. N., Crumley, E. T., Chuck, A., Nguyen, T., Faris, P., ... & Gramlich, L. M. (2016). Implementation of Enhanced Recovery After Surgery (ERAS) across a provincial healthcare system: the ERAS Alberta colorectal surgery experience. World journal of surgery, 40(5), 1092-1103.
3. Larach, D. B., Hah, J. M., & Brummett, C. M. (2022). Perioperative Opioids, the Opioid Crisis, and the Anesthesiologist. Anesthesiology, 136(4), 594-608.
4. Fay, E. E., Hitti, J. E., Delgado, C. M., Savitsky, L. M., Mills, E. B., Slater, J. L., & Bollag, L. A. (2019). An enhanced recovery after surgery pathway for cesarean delivery decreases hospital stay and cost. American Journal of Obstetrics and Gynecology, 221(4), 349-e1.
5. Lin, J., Hoffman, T., Badashova, K., Motov, S., & Haines, L. (2020). Serratus anterior plane block in the emergency department: a case series. Clinical Practice and Cases in Emergency Medicine, 4(1), 21.
6. Kamiya, Y., Hasegawa, M., Yoshida, T., Takamatsu, M., & Koyama, Y. (2018). Impact of pectoral nerve block on postoperative pain and quality of recovery in patients undergoing breast cancer surgery. European Journal of Anaesthesiology, 35(3), 215-223.
7. Kukreja, P., Bevinetto, C., Brooks, B., McKissack, H., Montgomery, T. P., Alexander, B., & Shah, A. (2019). Comparison of adductor canal block and femoral nerve block for early ambulation after primary total knee arthroplasty: a randomized controlled trial. Cureus, 11(12).
8. Meldrum, M. L. (2003). A capsule history of pain management. Jama, 290(18), 2470-2475.
9. John, G. M., McClain, C. D., & Mooney, D. P. (Eds.). (2014). Global surgery and anesthesia manual: providing care in resource-limited settings. CRC Press.
10. Gadsden, J. C. (2021). The role of peripheral nerve stimulation in the era of ultrasound-guided regional anaesthesia. Anaesthesia, 76, 65-73.
11. Griffin, J., & Nicholls, B. (2010). Ultrasound in regional anaesthesia. Anaesthesia, 65, 1-12.
12. Wilson, C. L., Chung, K., & Fong, T. (2017). Challenges and variations in emergency medicine residency training of ultrasound-guided regional anesthesia techniques. AEM Education and Training, 1(2), 158-164.
13. Tran, D. Q., Boezaart, A. P., & Neal, J. M. (2017). Beyond ultrasound guidance for regional anesthesiology. Regional Anesthesia & Pain Medicine, 42(5), 556-563.
14. Le, C. K., Lewis, J., Steinmetz, P., Dyachenko, A., & Oleskevich, S. (2019). The use of ultrasound simulators to strengthen scanning skills in medical students: a randomized controlled trial. Journal of Ultrasound in Medicine, 38(5), 1249-1257.
15. Venue Family R4- Messaging and Claims DOC2681095
16. Jang, T., Naunheim, R., Sineff, S., & Aubin, C. (2007). Operator confidence correlates with more accurate abdominal ultrasounds by emergency medicine residents. The Journal of emergency medicine, 33(2), 175-179.

*Venue Family, as referenced herein, includes Venue, Venue Go, and Venue Fit systems.

July 2023
JB20312XX

GE HealthCare