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Virtual reality training and modeling to aid in pre-procedural practice for thoracic nerve root block in the setting of a schwannoma

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A B S T R A C T

Virtual reality (VR) is a tool to aid with pre-procedural modeling and practicing for complex procedures with anatomic variation. Here we demonstrate a case of a 64-year-old woman with neuroforaminal compression from a schwannoma that was modeled in VR in order to facilitate pre-procedural training prior to a transforaminal epidural steroid injection. The modeling session allowed for determination of the optimal fluoroscopic angulation to avoid any contact with the mass or nerve root during the procedure. This case study demonstrates a way to incorporate VR in pre-procedural planning and practicing for both learners and experienced interventionalists.

1. Introduction

Virtual reality (VR) has been increasingly used in recent years to simulate real-world environments in the medical field. It has found notable utility in procedural specialties, facilitating skill development while avoiding undue patient harm [1–3]. Surgical training programs, in particular, have taken advantage of VR simulation for improving visual spatial ability [1] and laparoscopic surgery skills [2]. Multiple studies have demonstrated improvement in resident operative room performance following training with standardized VR simulation [1–3]. VR simulation has also rapidly emerged in anesthesiology and pain management training, such as in administration of spinal anesthetics [4] and peripheral nerve blocks [5], as well as facet joint blocks [6,7] and spinal cord stimulator lead placement [8], with similarly encouraging results. A particularly promising application of VR training in pain management lies in interventional planning for individualized cases, such as in patients with anatomical variation or deformity. Here, we discuss the case of a patient that underwent a thoracic nerve root block with pre-procedural planning facilitated by VR simulation.

2. Case report

A 64-year-old female presented with four months of ongoing right-sided thoracic pain. She was found on MRI to have a right-sided mass in the T11/12 foramen causing moderate to severe stenosis and compression of the exiting nerve root (Fig. 1). This was deemed inoperable in her home country, and she subsequently sought a second opinion from a United States-based spine surgeon who then referred her for a nerve block to confirm suspected diagnosis of schwannoma in the right T11/12 foramen prior to surgical planning. The patient endorsed a neuropathic upper back pain radiating anteriorly to the abdomen, consistent with the T11 distribution, and had trialed and failed conservative measures like neuropathic medications and physical therapy. The patient provided informed consent to both interventional therapy and having her case published for research purposes.

A transforaminal epidural steroid injection (TFESI) was planned with the goal of approximating the location of the schwannoma inferior to the T11 pedicle at around the 6 o'clock position. Interventional planning was conducted using *3D Organon VR Anatomy (Medis Media)* on an Oculus Quest 2 VR headset by simulating the location of the mass on a virtual spine and determining an optimal approach. Replication of the lesion was performed by manually sizing the tumor dimensions on MRI and then utilizing Tumor Modeling features in the software, which allows for 3D illustration of a mass with the ability to modify its location and dimensions. The model was then compared to the MRI images through a secondary slicing feature that allows for axial and sagittal slicing of the model. In modeling this case, the interventional team determined that a fluoroscopic view with right-sided oblique angulation to 15° would provide the optimal approach to the neuroforamen with minimal risk to infiltrating the mass or nerve root (video showing replication of recorded footage of pre-interventional session) using obliquity-controlled movements present within the anatomy sandbox's software. Angulation was

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Fig. 1. MRI T2 imaging of the mass.
A. Axial T2 imaging. Yellow circle represents the anatomical **area** of interest
B. Sagittal T2 imaging. Arrow pointing to the anatomical **area** of interest

further approximated taking still images from the recorded session showed here and compared to fluoroscopic images prior to needle insertion during the procedure. The patient then underwent the injection with the same team that performed the pre-procedural VR session. The same angulation was recreated during the procedure with appropriate proximal spread of 1 mL of omnipaque 180 radiocontrast dye visualized prior to depositing an injectate of 2 mL of 0.25% bupivacaine and 4 mg of preservative-free dexamethasone (Fig. 2). The patient suffered no immediate adverse consequences from the procedure. At four weeks follow-up, the patient reported significant, near complete, ongoing relief of her symptoms and she went on to continue follow-up with neurosurgery for operative planning.

3. Discussion

Here we demonstrate multiple advantages for applying VR simulation as part of interventional planning and using it for pre-procedural practice that can be executed with minimal technical expertise necessary. The software and hardware utilized are commercially available with current tools and do not require additional coding to implement. This facilitated real-time, actionable modeling, where multiple users were able to view available imaging and adjust the model to fit the patient's anatomy. This information then led to actionable consequence, allowing determination of the optimal fluoroscopic angulation, which may differ from what an interventionalist might conventionally utilize for TFESIs. Furthermore, implementation of this type of simulation could facilitate rapid training focused on learners across the spectrum of experience, from first-time

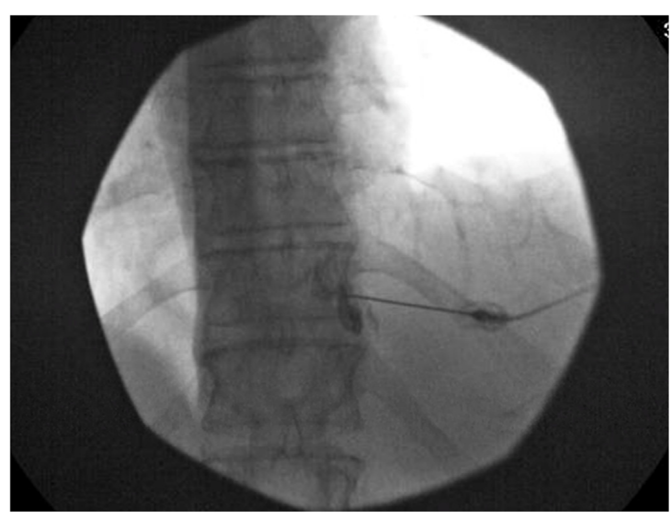

Fig. 2. Fluoroscopic image of transforaminal epidural steroid injection with radiocontrast dye to show safe infiltration of medication along the nerve root in question.

learners interested in modeling 3D anatomy to collaborative discussion between physicians, technologists and potentially patients.

Limitations of this approach currently involve the lack of automation with direct conversion from a patient's specific MRI findings to an interactive VR model. The procedural team here was able to compensate by recreating such findings using built-in software tools on an existing model. The currently available tools can replicate anatomic variations such as masses and osteophytes on VR simulation with the ability to modify size and simulate invasion to surrounding structures. In this particular case, the patient's mass was approximated on VR by translating its location and dimensions determined from MRI to a virtual environment. However, as the software in its current iteration lacks customizability of importing a spine model specific to the patient, this method is unable to exactly replicate the complexities of a patient's unique anatomy in simulation. As VR technology continues to develop, advances in the next generation may facilitate more exact replication of complex anatomy and even potentially automate this process in the virtual environment. While studies have demonstrated that fluoroscopy exposure and procedural duration can be decreased using supplementary training tools such as VR simulation [9,10], we propose future studies look to utilize VR for interventional planning focused on individualized cases, as it may improve patient satisfaction and outcomes.

Declaration of competing interest

Rohan Jotwani is a Scientific Advisor to *Medis Media*, but he owns no shares/financial interests with the organization and receives no funding from the organization.

Erik Wang has no conflicts of interest to report.

James Yu has no conflicts of interest to report.

John E. Rubin has no conflicts of interest to report.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.inpm.2023.100180.

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