Anesthesia-related Augmented Reality
Annotated Bibliography
December 7, 2018

Diana M.; Soler L.; Agnus V.; D'Urso A.; Vix M.; Dallemagne B.; Faucher V.; Roy C.; Mutter D.; Marescaux J., Pessaux P. (2017). "Prospective evaluation of precision multimodal gallbladder surgery navigation: virtual reality, near-infrared fluorescence, and x-ray-based intraoperative cholangiography". *Annals of Surgery* 266(5), pp. 890–897. DOI: 10.1097/SLA.0000000000002400.

OBJECTIVE: We aimed to prospectively evaluate NIR-C, VR-AR, and x-ray intraoperative cholangiography (IOC) during robotic cholecystectomy. BACKGROUND: Near-infrared cholangiography (NIR-C) provides real-time, radiation-free biliary anatomy enhancement. Three-dimensional virtual reality (VR) biliary anatomy models can be obtained via software manipulation of magnetic resonance cholangiopancreatography, enabling preoperative VR exploration, and intraoperative augmented reality (AR) navigation. METHODS: Fifty-eight patients were scheduled for cholecystectomy for gallbladder lithiasis. VR surgical planning was performed on virtual models. At anesthesia induction, indocyanine green was injected intravenously. AR navigation was obtained by overlaying the virtual model onto real-time images. Before and after Calot triangle dissection, NIR-C was obtained by turning the camera to NIR mode. Finally, an IOC was performed. The 3 modality performances were evaluated and image quality was assessed with a Likert-scale questionnaire. RESULTS: The three-dimensional VR planning enabled the identification of 12 anatomical variants in 8 patients, of which only 7 were correctly reported by the radiologists (P = 0.037). A dangerous variant identified at VR induced a "fundus first" approach. The cystic-common bile duct junction was visualized before Calot triangle dissection at VR in 100% of cases, at NIR-C in 98.15%, and in 96.15% at IOC.Mean time to obtain relevant images was shorter with NIR-C versus AR (P = 0.008) and versus IOC (P = 0.00000003). Image quality scores were lower with NIR-C versus AR (P = 0.018) and versus IOC (P ¡ 0.0001). CONCLUSIONS: This high-tech protocol illustrates the multimodal imaging of biliary anatomy towards precision cholecystectomy. Those visualization techniques could complement to reduce the likelihood of biliary injuries (NCT01881399).

Rochlen L. R.; Levine R., Tait A. R. (2017). "First-person point-of-view-augmented reality for central line insertion training: A usability and feasibility study". *Simulation in Healthcare* 12(1), pp. 57–62. DOI: 10.1097/SIH.0000000000000185.

INTRODUCTION: The value of simulation in medical education and procedural skills training is well recognized. Despite this, many mannequin-based trainers are limited by the inability of the trainee to view the internal anatomical structures. This study evaluates the usability and feasibility of a first-person point-of-view-augmented reality (AR) trainer on needle insertion as a component of central venous catheter placement. METHODS: Forty subjects, including medical students and anesthesiology residents and faculty, participated. Augmented reality glasses were provided through which the relevant internal anatomical landmarks were projected. After a practice period, participants were asked to place the needle in the mannequin without the benefit of the AR-projected internal anatomy. The ability of the trainees to correctly place the needle was documented. Participants also completed a short survey describing their perceptions of the AR technology. RESULTS: Participants reported that the AR technology was realistic (77.5%) and that the ability to view the internal anatomy was helpful (92.5%). Furthermore, 85% and 82.1%, respectively, believed that the AR technology promoted learning and should be incorporated into medical training. The ability to successfully place the needle was similar between experienced and nonexperienced participants; however, less experienced participants were more likely to inadvertently puncture the carotid artery. CONCLUSIONS: Results of this pilot study demonstrated the usability and feasibility of AR technology as a potentially important adjunct to simulated medical skills training. Further development and evaluation of this innovative technology under a variety of simulated medical training settings would be an important next step.

Won Y-J., Kang S-H. (2017). "Application of augmented reality for inferior alveolar nerve block anesthesia: A technical note." *Journal of Dental Anesthesia and Pain Medicine* 17(2), pp. 129–134. DOI: 10.17245/jdapm.2017.17.2.129.

Efforts to apply augmented reality (AR) technology in the medical field include the introduction of AR techniques into dental practice. The present report introduces a simple method of applying AR during an inferior alveolar nerve block, a procedure commonly performed in dental clinics.

Jeon Y.; Choi S., Kim H. (2014). "Evaluation of a simplified augmented reality device for ultrasound-guided vascular access in a vascular phantom." *Journal of Clinical Anesthesia* 26(6), pp. 485–489. DOI: 10.1016/j.jclinane.2014.02.010.

STUDY OBJECTIVE: To investigate whether a novel ultrasound device may be used with a simplified augmented reality technique, and to compare this device with conventional techniques during vascular access using a vascular phantom. DESIGN: Prospective, randomized study. SETTING: Anesthesiology and Pain Medicine departments of a university-affiliated hospital. PARTICIPANTS: 20 physicians with no experience with ultrasound-guided techniques. MEASUREMENTS: All participants performed the vascular access technique on the vascular phantom model using both a conventional device and the new ultrasound device. Time and the number of redirections of the needle until aspiration of dye into a vessel of the vascular phantom were measured. MAIN RESULTS: The median/interquartile range of time was 39.5/41.7 seconds versus 18.6/10.0 seconds (P ¡ 0.001) and number of redirections was 3/3.5 versus 1/0 (P ¡ 0.001) for the conventional and novel ultrasound devices, respectively. CONCLUSION: During vascular access in a vascular phantom model, the novel device decreased the time and the number of redirections significantly. The device successfully improved the efficiency of the ultrasound-guided vascular access technique.

Al-Deen Ashab H.; Lessoway V. A.; Khallaghi S.; Cheng A.; Rohling R., Abolmaesumi P. (2013). "An augmented reality system for epidural anesthesia (AREA): Prepuncture identification of vertebrae." *IEEE Transactions on Bio-medical Engineering* 60(9), pp. 2636–2644. DOI: 10.1109/TBME.2013.2262279.

We propose an augmented reality system to identify lumbar vertebral levels to assist in spinal needle insertion for epidural anesthesia. These procedures require careful placement of a needle to ensure effective delivery of anesthetics and to avoid damaging sensitive tissue such as nerves.

In this system, a trinocular camera tracks an ultrasound transducer during the acquisition of a sequence of B-mode images. The system generates an ultrasound panorama image of the lumbar spine, automatically identifies the lumbar levels in the panorama image, and overlays the identified levels on a live camera view of the patient's back. Validation is performed to test the accuracy of panorama generation, lumbar level identification, overall system accuracy, and the effect of changes in the curvature of the spine during the examination. The results from 17 subjects demonstrate the feasibility and capability of achieving an error within clinically acceptable range for epidural anaesthesia.

Al-Deen Ashab H.; Lessoway V. A.; Khallaghi S.; Cheng A.; Rohling R., Abolmaesumi P. (2012). "AREA: An augmented reality system for epidural anaesthesia." In: *Annual International Conference of the IEEE Engineering in Medicine and Biology Society*. Vol. 2012. San Diego, CA: IEEE Engineering in Medicine and Biology Society, pp. 2659–2663. DOI: 10.1109/EMBC.2012.6346511.

PURPOSE: Spinal needle injection procedures are used for anesthesia and analgesia, such as lumbar epidurals. These procedures require careful placement of a needle, both to ensure effective therapy delivery and to avoid damaging sensitive tissue such as the spinal cord. An important step in such procedures is the accurate identification of the vertebral levels, which is currently performed using manual palpation with a reported 30% success rate for correct identification. METHODS: An augmented reality system was developed to help identify the lumbar vertebral levels. The system consists of an ultrasound transducer tracked in real time by a trinocular camera system, an automatic ultrasound panorama generation module that provides an extended view of the lumbar vertebrae, an image processing technique that automatically identifies the vertebral levels in the panorama image, and a graphical interface that overlays the identified levels on a live camera view of the patient's back. RESULTS: Validation was performed on ultrasound data obtained from 10 subjects with different spine arching. The average success rate for segmentation of the vertebrae was 85%. The automatic level identification had an average accuracy of 6.6 mm. CONCLUSION: The prototype system demonstrates better accuracy for identifying the vertebrae than traditional manual methods.

Del Castillo A. S., Sardi N. S. (2012). "Augmented reality: Can it enrich the practice of anesthesiology?" *Revista Brasileira de Anestesiologia* 62(6), pp. 887–888. DOI: 10.1016/S0034-7094(12)70190-3.

A letter to the editor positing how AR might be used in anesthesiology.

Moore J.; Clarke C.; Bainbridge D.; Wedlake C.; Wiles A.; Pace D., Peters T. (2009). "Image guidance for spinal facet injections using tracked ultrasound." *Medical Image Computing and Computer-assisted Intervention* (Pt 1), pp. 516–523.

Anesthetic nerve blocks are a common therapy performed in hospitals around the world to alleviate acute and chronic pain. Tracking systems have shown considerable promise in other forms of therapy, but little has been done to apply this technology in the field of anesthesia. We are developing a guidance system for combining tracked needles with non-invasive ultrasound (US) and patient-specific geometric models. In experiments with phantoms two augmented reality (AR) guidance systems were compared to the exclusive use of US for lumbar facet injection therapy. Anesthetists and anesthesia residents were able to place needles within 0.57 mm of the intended targets using our AR systems compared to 5.77 mm using US alone. A preliminary cadaver study demonstrated the system was able to accurately place radio opaque dye on targets. The combination of real time US with tracked tools and AR guidance has the potential to replace CT and fluoroscopic guidance, thus reducing radiation dose to patients and clinicians, as well as reducing health care costs.