

Augmenting the Anesthesiologist's Cockpit with Head-mounted Displays for Image-guided Procedures: Are We There Yet?

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The pace of technological advances in diagnostic imaging and point of care ultrasonography is staggering. Head-mounted displays, analogous to the heads-up display in use by jet pilots, can be integrated with imaging devices to overlay the image in the user's field of view. There is a pressing need to study the technology and understand its role in clinical practice, particularly in improving patient safety and technical efficiency. In this issue of *ANESTHESIOLOGY*, Jang *et al.* examine adopting a head-mounted display consisting of smart glasses during radial artery catheterization in pediatric patients younger than 2 yr.¹ The head-mounted display projects a real-time ultrasound image directly in front of the operator's field of view, allowing the operator to visualize the procedure field and the ultrasound display side by side without head movement.

We commend the authors on sound study design and conduct of a prospective randomized study of 116 pediatric patients to address the critical question of impact on procedure success, complication rates, and ergonomic satisfaction. The authors found a higher first-attempt success rate (88% *vs.* 72%), lower procedure time (median 33 *vs.* 43 s), lower complication rates, including catheter malfunction (5% *vs.* 29%), and higher ergonomic satisfaction (70% *vs.* 21%) in the head-mounted display group compared to the control group. The authors' preference was to use the transfixation technique, where the needle punctures the anterior and posterior walls of the radial artery, and applied it to both study groups.



“[There is] a growing body of evidence supporting the use of head-mounted displays to guide patient care, particularly during interventional procedures.”

This elegant prospective trial offers objective insight into the potential impact of head-mounted displays on the overall success and provider ergonomics in anesthetic care during technically complex procedures. Head-mounted displays and augmented reality devices have been evaluated in various settings, including placement of ultrasound-guided peripheral nerve blocks, for use in intraoperative patient monitoring and placement of central venous catheters.²⁻⁴ It is essential to distinguish between augmented reality devices, consisting of a self-contained computer unit within a head mount that can function independently, and head-mounted displays, a computer display worn over the head that projects images through an optical engine. According to the manufacturer, the head-mounted display in this study requires a wired connection *via* either a Universal Serial Bus Type C cable to achieve high-definition image quality (720p) or a high-definition multimedia interface (HDMI) to achieve full high-definition image quality (1080p). The investigators note they used a high-definition multimedia interface cable to reduce ultrasound imaging delay.

Arterial cannulation in young pediatric patients can be particularly challenging due to the small diameter of the radial artery and high tissue elasticity. Ultrasound imaging can facilitate cannulation through identification of anatomy and real-time needle visualization, while also adding logistical challenges such as positioning the display in the provider's field of view, a feat that is often easier said than done. Head-mounted displays address some of the challenges of

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using ultrasound devices in the operating room, specifically related to the spatial relationship between the provider and the ultrasound display during the procedure. For example, if a provider decides to switch sides from right to left after an unsuccessful attempt, the ultrasound device needs to be moved to the opposite side of the provider. Wireless head-mounted displays would follow the provider wherever they go, thus reducing the need to move equipment around the patient. The ergonomics of alternating the view of the procedure field and the ultrasound screen can be challenging. Another advantage of head-mounted displays is that they are not affected by glare or room lighting conditions.

How will these findings change our current practice? Jang *et al.* add to a growing body of evidence supporting the use of head-mounted displays to guide patient care, particularly during interventional procedures. The U.S. Food and Drug Administration (Silver Spring, Maryland) is conducting public workshops to understand the role of augmented and virtual reality in medical care, and its role in regulating medical devices that incorporate head-mounted display technology has yet to be defined.⁵ Technological advances always raise more questions than the ones that are addressed by the invention. Will head-mounted displays be tethered to specific medical equipment such as ultrasound, fluoroscopy, or patient monitors? Will a communication standard emerge that allows all medical devices to connect to a unified head-mounted display platform? Will the head-mounted displays require a wired connection for data and power supply, or will they be truly wireless devices? How will wired devices affect provider mobility? If they are wireless, how much lag time is acceptable for imaging, and how reliable will the battery life be? Jang *et al.* reported a lag time (less than 0.1 s) initially when utilizing Bluetooth wireless technology that became available with software updates. Delays in image processing and display during procedures, such as continuous needle tip visualization during vascular access procedures, could lead to procedure failures and potentially to patient injury.

Head-mounted display technology also opens the door to telemedicine considerations such as remote consultations during complicated procedures and developing educational programs. Should learners focus on traditional ultrasound imaging with a dedicated device or begin learning with head-mounted displays? How will this technology impact education and skill maintenance? Head-mounted displays can overlay just-in-time information such as checklists and procedure steps onto the procedural field. However, one has to recognize that there is a learning curve for many operators to use head-mounted displays, and the additional information may increase the cognitive load for procedures. Furthermore, infection prevention and control policies need to be developed for head-mounted displays, especially if the devices are intended to be shared.

The authors should be commended for studying the ergonomic impact on the providers performing the procedures. The authors demonstrated that the head-mounted display positively impacted head position and body posture during the procedure. However, not all head-mounted displays are designed equally. Some are bigger than others and may not fit each user the same. Donning and doffing the head-mounted display may pull on the surgical cap and masks worn by the individual or potentially damage personal protective equipment. These investigational devices may not be cost-effective and may increase the complexity of administrative and maintenance workflows in perioperative care. Medical device manufacturers will undoubtedly incorporate head-mounted display technology in their products. What role will anesthesiologists play in developing and implementing these technologies into clinical practice and graduate medical education programs? The future is here, and it is up to us to take ownership to achieve our ultimate goal of improving patient safety and outcomes.

Competing Interests

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References

1. Jang Y-E, Cho S-A, Ji S-H, Kim E-H, Lee J-H, Kim H-S, Kim J-T: Smart glasses for radial arterial catheterization in pediatric patients: A randomized clinical trial. *ANESTHESIOLOGY* 2021; 135:612–20
2. Przkora R, Mora J, Balduyeu P, Meroney M, Vasilopoulos T, Solanki D: Ultrasound-guided regional anesthesia using a head-mounted video display: A randomized clinical study. *Pain Physician* 2021; 24:83–7
3. Drake-Brockman TF, Datta A, von Ungern-Sternberg BS: Patient monitoring with Google Glass: A pilot study of a novel monitoring technology. *Paediatr Anaesth* 2016; 26:539–46
4. Kaneko N, Sato M, Takeshima T, Sehara Y, Watanabe E: Ultrasound-guided central venous catheterization using an optical see-through head-mounted display: A pilot study. *J Clin Ultrasound* 2016; 44:487–91
5. Center for Devices and Radiological Health Public Workshop – Medical Extended Reality: Toward best evaluation practices for virtual and augmented reality in medicine. Available at: <https://www.fda.gov/media/136890/download>. Accessed June 8, 2021.