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An Educational Module Utilizing Smart Glass Technology as an Adjunct During Anesthesia and Procedural Tasks to Decrease Medical and Human Errors in the Perioperative Period

A DNP Project Presented to the Faculty of the
Nicole Wertheim College of Nursing and Health Sciences

Florida International University

In partial fulfillment of the requirements
For the Degree of Doctor of Nursing Practice

By

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Abstract

Background: Patients presenting for surgical procedures have increasingly complex medical co-morbidities and require vigilant monitoring. The anesthesia provider's direct view of the patient and monitors can be obstructed by the surgical positioning or the room's configuration in the intraoperative period. The anesthetist may be unable to view the display screen while performing intricate tasks such as arterial catheterization, direct laryngoscopy, US-guided central venous access, peripheral nerve blocks, and regional anesthetic procedures. Smart Glasses (SG) improves patient care and safety in the complex anesthesia realm as the technology affords the provider mobility, an unobstructed view of the hemodynamics, a direct view of the ultrasound screen, decreased excessive head shifting and improving success with procedural tasks and peripheral nerve blocks.

Methods: The primary methodology of the quality improvement project is to implement an online educational module to anesthesia providers that focuses on the utilization of the smart glasses as an adjunct during anesthesia and procedural tasks to decrease medical and human errors in the perioperative period. Qualtrics pre- and post-test surveys were employed to gauge the efficacy of the educational module and to evaluate the influence on anesthesia provider knowledge and attitudes.

Results: Findings pointed to a significant increase in anesthesia provider knowledge and overall attitudes towards using smart glasses during the administration of anesthesia. 5 participants completed the pre-test and post-test (n=5). The average amount of anesthesia providers inclined to utilize smart glasses during the provision of anesthesia was 40.00% in the pre-test and 60.00% in the post-test. Overall, knowledge of the benefits of the smart glass technology to the anesthesia provider also increases from 40.00% in the pre-test to 70.00% in the post-test.

Conclusion: All studies demonstrated that SG could improve perioperative patient management and there are several applications of SG technology in the field of anesthesia. Vital sign streaming with SG or similar platforms is feasible and may enhance procedural situational awareness. The provider can wirelessly transmit assessment data to the attending, providing flexibility and increasing efficient informed remote decision-making. SG increases the first-time intubation success, documents airway assessment, and captures more comprehensive data. The SG assist in ultrasound-guided cannulation of an artery or central vein as it gives the user a direct view of the ultrasound machine without the user having to shift the head or change their view. The Smart Glasses enable users to share what they see with people and other users in other physical places. The SG improves US-guided regional anesthetic block's first-attempt success rate, provider ergonomics, and reduced first-attempt procedure time and overall complication rates.

Keywords: Smart glasses, Google Glass, Head-Worn Display Device, Head-Mounted Display, Augmented Reality-Assist Device, Anesthesia Management, Perioperative Period.

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Introduction

Problem Identification

The field of anesthesia is one of the most high-tech, multifaceted, and advanced care environments. Patients treated are often undergoing complex scheduled or emergency surgeries.[1] Surgical patients often have a myriad of complex health issues that further complicate their care.[2] Extensive invasive hemodynamic monitoring outside the basic vital function may be required depending on the complexity of the procedure and the patient's comorbidities. To maximize patient's care and to aid the early detection of disparaging events, standard vital functions are monitored for patients undergoing anesthesia. Standard vital monitoring includes heart rate, rhythm, oxygen saturations, respiratory rate, and blood pressure.[2] In the complex care environment, patient safety is dependent on the competence and reliability of the technology employed. The anesthetist is responsible for establishing invasive lines, performing regional pain alleviating techniques, maintaining adequate ventilation and overall patient management during the administration of anesthesia.[1]

A study by Ormerod et al.[3] found that one of the biggest hindrances to safety in the operating room to the anesthesia provider while performing routine or emergency procedures is the shifting of the providers attention back and forth from the monitors to the patient.[3] Furthermore, there has been a long documented history of human issues related to traditional patient monitors used in anesthesia.[3] Traditional patient monitors are often oddly positioned away from the patient, making it difficult for the anesthesia provider to assess the patient while keeping the monitors in view. Additionally the anesthetist may be unable to view the display screen while performing intricate tasks such as arterial catheterization, ultra-sound guided central

venous access, direct laryngoscopy, ultra-sound guided peripheral nerve blocks, and other regional anesthetic procedures.[4] To prevent the anesthesia provider from missing essential changes in patient status, auditory alarms are proposed, but unfortunately alarms are often turned off or ignored because it is sometimes difficult to differentiate, false and unhelpful.[4]

A study conducted in 2019 by Tscholl et al included 120 anesthesia providers that focused on problems with traditional patient monitoring alarms and were commonly identified as problematic.[5] Twenty-two interviewees (18%) cited alarm limits and configuration as significant problems. False alarms were mentioned as problematic by 18 participants (15%). Twelve (10%) participants specifically used the term "alarm fatigue" and acknowledged the danger of desensitization, which may cause a critical events to go undetected.[5] Participants expressed problems distinguishing the sound of different audio alarms and discerning which of the two alerts is more serious, especially when performing intricate procedures and the direct monitor view is obscure.[5]

To successfully establish vascular access or place a regional block using ultrasound-guided technology, superb hand-eye coordination, knowledge of the procedure field anatomy, and view of ultrasound screen are necessary.[6] To ensure proper alignment of the needle tip, target vessel and ultrasound probe, frequent eye and head movements between the ultrasound screen and procedure field are required. This added head and eye shifting disrupts the control on the ultrasound probe, increases procedure time and may possibly lead the loss of the target vessel image.[6] The anesthesia provider may experience musculoskeletal fatigue with the increased repetitive movements if the procedure time is unnecessarily extended. Approximately ninety-eight percent of anesthetist from a recent study reported work-related musculoskeletal pain.[6]

Background

Anesthesia monitoring was performed primarily through traditional assessment such as visual inspection, auscultation, and palpation before modern electronic patient monitors were invented.[4] Visual cyanosis detection were deemed unreliable in the 1950s, and later in the 1980s, similar findings reported that the assessment of ventilation or hypoxia through clinical signs alone was also grossly inadequate.[4] At the dawn of the 1950s, the development of hi-tech monitoring devices that could measure an increasingly extensive range of functional variables was facilitated through computer and electronic technology advances. All governing professional societies now mandate the use of monitoring devices during the administration of all anesthetics.[4] Anesthesia monitoring has become increasingly complex and, unfortunately, has led to many incidents due to equipment misuse, with a landmark study attributing 82% of equipment incidents to preventable human errors.[4] Since then, researchers and engineers have increasingly used human factors techniques to improve the design and safety of advanced anesthesia equipment in the operating room.

Human factor problems associated with patient monitors have been extensively documented in the literature. Monitors are often awkwardly positioned outside the provider's view in the operating room. The chief concern is that the anesthesia provider may miss important events on the monitor when their attention is overloaded during busy periods. Auditory alarms were presented as a reliable tool for alerting the anesthesia provider to deviations from pre-set norms.[4] Automatic acoustic alerts, are designed to capture the anesthetist attention so that necessary changes are not missed whenever the patient's vital signs (VS) differ from a predetermined range.[3] Auditory alarms are quite problematic despite their simplistic nature. Up to 90% of alarms in the critical care environment have been reported as false positives – potentially leading clinicians to become dangerously desensitized. Auditory alarms have been

accused of being offensively loud and challenging to discern.[4]

Scope of the Problem

The safety of anesthesia has evolved substantially yet unfavorable sentinel events still occur. Presently, anesthesia deaths have declined to about one in every million anesthetics provided in the United States.[7] This noteworthy reduction can be credited to patient safety amplification efforts, the development and intensification in the use of checklists, protocols, teamwork, and improved monitoring of patient's vital signs. Unfortunately, patients still suffer difficulties related to communication, monitoring and during anesthesia care despite best efforts.[1] Perioperative morbidity and mortality related to anesthesia includes numerous issues. A thorough preoperative assessment is crucial because many times the development of many adverse events can be attributed to the patient's preexisting medical conditions and distinctive health condition. While optimization of patient preexisting health condition is not always possible, having the appropriate intraoperative tools can help in increasing patient safety. The United States Office of the Inspector General in 2010 provided an evidence-based review that assessed the incidence of adverse events that contributed to the death of hospitalized Medicare patients or caused harm. Expert reviewers determined that 44% of adverse events that resulted in patient harm were preventable.[8] Other approximations of preventable anesthesia-related adverse events range between 50% and 60%.[8] The goal of this quality improvement project is to improve anesthesia provider vigilance, decrease anesthesia-related complications, and ensure that each patient has a safer surgical anesthetic experience.

Consequence of the Problem

The consequence of not accepting new technology towards patient safety improvements and assimilating them in clinical practice could lead to fatal consequences. Medical errors are

among the top three causes of patient deaths in the United States, with most of those deaths being deemed preventable, despite technological advancements.[8] Investigators have determined that 123 closed malpractice claim files from the American Association of Nurse Anesthetists (AANA) database that involved Certified Registered Nurse Anesthetists could have been prevented.[8] Infringements of the AANA Standards for Nurse Anesthesia Practice includes errors communication failures and errors in judgment. [8]

Another challenge is to the supervising anesthesiologist or the attending supervising multiple operating rooms. When an unfavorable incident occurs and the attending is contacted, detailed account of the issue surrounding the problem and the patient's current condition must be meticulously communicated so that the attending can fully comprehend the situation and make the appropriate recommendation. The information must be communicated efficiently. Inefficient or inaccurate communication is a serious risk to patient safety. It is approximated that 43% of adverse clinical events in the US are attributable to communication failures within the team care model.[9]

The vigilance of the anesthesia provider is the central component of the care they provide to patients under general anesthesia. Anesthesia providers are the eyes and ears of unresponsive patients undergoing anesthesia. The provider must keenly monitor the patient, anticipate needs, and frequently communicate with the other members of the surgical team. Research shows that integration of the smart glass technology in clinical practice could revolutionize the way anesthesia providers care for their patients. Smart glass (SG) increases patient safety by increasing access to patient information.[3]

Knowledge Gaps

According to an article written by Franzen et al., point-of-care ultrasonography and diagnostic imaging technology is advancing at astounding rates.[10] SG technology superimposes and integrates images over the user's field of view.[10] The authors surmise that there is an urgent need to better understand the technology and its role in clinical practice, particularly in improving efficacy and patient safety. [10] Recent research have indicated that smart glass technology can be applied to numerous medical applications, including expediting workflow, and facilitating hands-free communication. The new technology has been recommended in a surgical setting to aid ultrasound-guided central line placement, performing regional blocks, establishing arterial cannulations and the overall expediting of the workflow. [11]

The SG's ability to aid vital sign (VS) monitoring offers the potential to improve patient safety during conscious sedation by decreasing complications.[12] Though, the benefits and practicability of the new device are still to be determined.[11] Most of the reports on the benefits of the new technology have been conducted in simulated controlled environments expediting workflow. An extensive review of current literature determines the clinical use is the smart glass technology is still very limited. [12]

Proposed solution

Anesthesia providers employ varying techniques to support the delivery of safe care when surveilling patients. It is through the stark vigilance of healthcare professionals that patients who are temporarily incapacitated by anesthesia during surgery are supported and protected from harm. The employment of the appropriate technology can foster efficacy and aid vigilance. For widespread practical adaptation, the new device must improve safety, add value, and demonstrate usefulness.[1] Smart glasses (SG) have been suggested in the complex anesthesia environment because the device affords the user easy access to patient information, mobility, and

hands-free interaction. SGs are a wearable technology that gives users sustained, hands-free access to information and can receive and transmit data wirelessly.[3] The smart device is worn like a regular pair of eyeglasses mounted on the head, but unlike regular glasses, the SG displays information in the user's field of view through a prism in real-time.[3,6] SGs are computing devices that host various applications that can be tailored specifically to anesthesia.[4] Through apps, the SG can be used as a camera, displays images, texts, and communicates using Wi-Fi and Bluetooth technology.[4] The information can be sent and received through a local network or online.[4] Research shows that the field of anesthesia is ideal for SG technology since continuous monitoring, attention, mobility, timely access to information, and hands-free interaction are required.[5] The SG can capture pictures and videos and communicate through voice or a combination of both.[5] The glasses also permit the provider to share what they see with other providers who are physically not in the room, perhaps preoccupied in another room or facility. The opinion of skilled experts would potentially be only a voice command away. This flexibility provides a more informed, faster, and safer decision-making process.[4] The smart glass can be controlled by physical input, touch, eye-blink detection, and voice.[5] The SG technology allows the anesthesia provider to continuously monitor patient data while performing other pertinent tasks such as placing invasive lines, talking to other members of the surgical team, mixing or titrating medications, and avoiding the need to turn the head away from the patient or task to view the monitor display.[2]

The use of SG by the anesthesia provider during procedures decreasing head and eye shifting from the patient to the monitors, thus improving the anesthesia provider ergonomics. Studies also showed that many anesthetists felt in control when using the SG for monitoring patients' vital signs. Changes in VS were also identified faster than by using the stationary

monitor.[11] The appropriate use of SG technology can improve the quality of patient care and reduce avoidable medical errors. To continue providing high-quality care to a changing patient population, the anesthesia profession must adapt to technological advancement. The SG technology offers a system that can change how anesthesia providers care for their patients and drastically improve quality of care while reducing adverse events. The following PICO question was formulated to guide this quality improvement project (P) In patients receiving anesthesia (I), does the utilization of smart glasses in the perioperative period (C) compared to no smart glasses (O) improve situational awareness, decrease medical, human errors, adverse events, increase quality of care, provider knowledge, and attitude?

Summary of the Literature

Eligibility Criteria

The selection of studies for this literature review required an extensive search due to research on smart glass technology being in its preliminary stages. Its use has yet to be widely adopted into clinical practice. Despite paucity, with the guide of the context, inclusion and exclusion criteria were broadened to generate sufficient literature. This study excluded literature reviews, meta-analyses, and systematic reviews. Articles centered primarily on the use of the smart glass technology by non-anesthesia providers that had very little relevance to the field of anesthesia were also eliminated. Only articles written in English and published within the last ten years with full-text availability were considered for evaluation. Other inclusion parameters were primary studies centered on the application of smart glass use in anesthesia. The Florida International University (FIU) library search engine was used to access the pertinent databases that facilitate the clinical problem. With the proper Boolean operators, keywords used in this

search included variations and combinations of the following: Smart glass, Google Glass, head-worn device, augmented reality technology, and anesthesia management.

Information Sources

The Cumulative Index of Nursing and Allied Health Literature (CINAHL), Google Scholar, and PubMed were the primary search engines employed and were accessed via the Florida International University (FIU) library database. A hand search of the reference list of each study was also conducted to identify any relevant study that had not been found in the original search; this process is called the ancestry method. The hand search yielded two additional studies for a total of 15 articles utilized for this quality improvement project.

Search Strategy

Initially the keyword search conducted within the PubMed, MEDLINE and CINAHL databases included the following terms: ("Smart Glass" OR "Google Glass") AND/OR ("Head-Worn Display" OR Head-Worn Device OR "Head-Mounted Video Display") AND/OR ("Augmented Reality-Assisted Device" OR "Augmented Reality Technology" AND ("Anesthesia"). The keywords were utilized independently or collectively and with the Boolean operators "OR" and "AND" interchangeably in the literature search to yield a total of 93 articles, 8 from MEDLINE, 6 from PubMed and 79 from CINAHL. Upon modification of the publication time frame to a range between 2013-2022, the search was refined to a total of 53 articles. Of the 53 articles remaining for analysis 8 duplicate articles were removed. Of the remaining 45, further investigation 33 articles did not meet the inclusion criteria. Research articles did not meet the inclusion criteria based on type of publication, meta-analysis, scoping reviews, or systematic review, failing to be exclusive to anesthesia providers and also articles not written in English. A total of 12 articles were selected for use from PubMed, CINAHL and MEDLINE that focused on

smart glass use in anesthesia during the intraoperative period.

Results of Individual Studies

Effects on situational awareness

The healthcare system in Germany is comparable to the health system in the United States, where experienced senior anesthesiologists supervise resident anesthesiologists and certified registered nurse anesthetists who provide anesthesia to a single patient.[1] Given the colossal responsibility of the supervising anesthesiologists charged with managing the entire operating suites, the supervising provider must be acutely aware of the status of multiple patients. This can be challenging if the supervising anesthesiologist is distant from the patient's bedside or a central monitoring station. A proof-of-concept study by Schlosser et al.[1] explored how supervising anesthesiologists could benefit from using the head-worn device (HWD) to monitor multiple patients. The authors determined that although HWDs have already been tested in several clinical environments, they have not been tested in multiple patient monitoring scenarios.[1] Since HWD facilitates multiple patient monitoring, the authors of the article hypothesized that the HWD could improve the supervising anesthesiologist’s awareness of their patients in a hands-free, mobile manner, even in sterile situations.[1]

Schlosser et al[1] used a crossover design to evaluate how supervising anesthesiologists used an HWD to monitor multiple patients' vital signs in an operating suite. The researchers determined whether the continuous availability of vital signs and alarms on the HWD improved or worsened the supervising anesthesiologists' situation awareness, compared with solely using the central monitoring station.[1] Situation awareness is critical in anesthesia; it supports the fast detection of patient deterioration and subsequent treatment.[1] The authors define situational awareness as the perception of elements in the environment (level 1), the comprehension of their

meaning (level 2), and the understanding of future implications (level 3).[1] In multiple patient monitoring, good situation awareness indicates that the supervising anesthesiologist knows "what is going on" in the operating rooms and can detect negative trends early, react appropriately, and prevent critical situations.[1] Level 1 situation awareness was quantitatively assessed by instructing the anesthesiologists to press a push button whenever they noticed a patient alarm. Level 2 and level 3 situational awareness was assessed through conducting qualitative interviews.[1]

The study was conducted in a large operating suite of the University Hospital of Würzburg. The hospital has 1450 beds and prides itself on being a teaching facility.[1] Fifteen to twenty-five surgeries are performed daily, mostly in urology and orthopedics. After informed consent was acquired, eight anesthesiologists who regularly work in the supervisor role participated in the study (seven males, age *median* = 37.5-year, work experience as anesthesiologist *median* = 9.5 years).[1] The supervising attendings were educated on the operations of the HWD and about the study's goal. Whenever the attending noticed an alarm or an anomaly from any of the six operating rooms, they were instructed to push a button worn over their scrubs.[1] The participating attendings were randomly allocated to one of two groups, the control and the HWD group. Randomization was done by pulling numbered from an urn. Standard monitoring equipment was used in the control group.[1] In the HWD group, the anesthesia provider wore the HWD along with using the standard monitoring equipment. The two supervising attendings alternated and worked in 3-hour increment. A 20–30-minute interview centered on the supervising attendings individual experience wearing the HWD. The semi-structured interviews were analyzed with thematic analysis methodology.[1] All red and yellow alarms from the physiological monitoring systems installed in the six operating rooms were defined as alarms.[1] The percentage of patient alarms noticed by the anesthesiologists was

the dependent variable.[1] All alarms were displayed as colored text on the central monitoring station. An auditory signal was played in the individual operating room and at the central monitoring station when an alarm occurred. An alarm was only considered detected if the anesthesiologist pressed the button within 10 seconds after the alarm occurred.[1] Quantitative data analysis revealed that the attendings detected a significantly larger percentage of patient alarms in the HWD condition, for a median [IQR] of 66.7% [53.1%, 93.1%] compared with the control condition, 7.1% [4.7%, 8.8%], $P = 0.028$. The anesthesiologists noticed more potentially relevant information with the HWD than without the HWD (level 1 situation awareness).[1] The median [IQR] number of patient alarms occurring within the 3-h periods in the HWD condition, 42.0 [33.3, 45.3], and in the control condition, 40.5 [34.5, 60.3], showed no significant difference, $P = 0.753$. The median [IQR] time required by the anesthesiologists to detect and report an alarm in the HWD condition, 4.07 s [3.26 s, 4.91 s], and in the control condition, 4.12 s [0.71 s, 6.63 s] showed no significant difference, $P = 0.917$.[1] The qualitative data was inadequate to conclude an increase in level 2 and level 3 situational awareness.[1] Nevertheless, all attendings indicated that the HWD increase level 2 situational awareness as it enhanced their understanding of the environment. Seven supervising attendings indicated that a more appropriate assessment could be made while wearing the HWD than without it. For example, when a supervising anesthesiologist received a phone call from a junior provider regarding a change in patient status the attending could quickly analyze the situation by quickly and seamlessly accessing the patient's vital functions on the HWD and offer their expertise.[1] Furthermore, six providers denoted that the absence on vital function on the HWD indicated that the case ended, and the patient was transferred to the post-operative unit, increasing efficiency.[1] Four anesthesiologists overtly stated that the HWD helped them "to understand what was going on in the unit."[1] Seven

participants indicated an increase in their level 3 situational awareness as the device helped them detect a declining trend in vital functions even before alarm thresholds are reached, thus permitting early intervention. The providers enhanced level 3 situational awareness by positively influencing future action. One anesthesiologist stated that the HWD helped him predict a critical situation.[1]

Similarly, a study by Kuge et al[2] also hypothesized that using the HWD technology could improve the supervising anesthesiologist's situational awareness as the device permits convenient, hands-free, and unobtrusive information retrieval.[2] Access to basic vital sign information from several patients can be accessed by the anesthesiologist wearing the HWD.[2] Two supervising anesthesiologists usually oversee six junior anesthesiologists who manage separate operating suites in the hospital.[2] Still, an adverse event can occur at any time and in any room, requiring urgent intervention. Consequently, a means for the in-suite anesthesia provider to swiftly alert the supervising attending to seek guidance and support should be established.[2] The HWD technology was evaluated in a completely functional, high-fidelity, full-scale computer-controlled simulator setting.[2] Physiological data for six patients including the patient stimulator were clearly defined[2] and included the procedure to be performed, medical history, age, sex, and weight. The total duration of each study was 1.5 hours.[2] The study was facilitated by two human-computer interaction (HCI) researchers and a senior anesthesiologist who had experience as both a supervisor and a medical expert.[2] After informed consent was obtained, the partakers tried on the HWD and confirmed a comfortable fit.[2] The participants were told to monitor the one patient represented by the computer-controlled patient simulator manikin to supervise further procedures in remote rooms. The experiment was observed through a one-sided mirror and a live video recording.[2] During the simulation, the manikin's utterances were read out

loud by one of the HCI researchers according to a predefined script. The medical expert answered all incoming calls from the participant, made outgoing calls according to the script, and did not communicate any vital sign data or other information accessible in the HWD without being asked. However, the medical expert provided the participant with all the necessary data upon request. The scenario lasted 20 minutes. Immediately following the scenario, two interviews were conducted. First, the medical expert asked the participant to summarize each patient's events during the scenario and to indicate which patient they would have attended to after the scenario. Second, both HCI researchers asked the participant predetermined questions from a protocol about the practicability and user experience of the prototype but also encouraged the participants to describe their impressions and experiences made during the scenario.[2]

Data were analyzed using thematic analysis; the 20-minute video recordings of the scenario and the 8 to 14-minute-long interviews about the HWD were also independently reviewed.[2] To establish themes, both analysts sorted the data of three participants in an affinity diagram. One overarching theme was the improvement of situation awareness; two participants explicitly stated that they would not have become aware of some situations without the HWD.[2] Another stated that "if you have a couple of patients who might become unstable and you want to keep an eye on these operating rooms, you have to either sit [in front of the central monitoring] or permanently walk from one room to the next." In contrast, with the HWD it is possible to "take the monitoring with you."[2]

The HWD affected the perception of environmental changes and information (SA level 1). All participants showed clear reactions to alarm notifications. The data suggest that, to a high degree, the participants successfully understood the situation in other rooms.[2] Three participants indicated that due to the HWD, they "did not need to ask as many questions when on the phone

"suggesting that they already had access to the most relevant information through the HWD.[2] Second, the HWD affected the comprehension of information meaning (SA level 2).[2] Several participants mentioned that the historical trend data on a room's detailed screen was well-suited to judge whether changes in vital sign parameters were sudden or happened more slowly over time.[2] Therefore, overwhelmingly, the data suggested that participants better understood what was happening in the other rooms. In line with Schlosser et al's [1] field study results that participant perceived significantly more alarms with the HWD than without the HWD, Kuge et al's qualitative data also suggest that SA level 1 was improved.[1]

Smart glasses improvement to central venous access

A study by Wu et al[3] aimed to explore the potential advantages of the smart glass technology to medical professional at varying level of training to perform an ultrasound-guided central venous access. The ultrasound device use has dramatically improved success rates in performing many invasive procedures and had drastically decrease complication risks. The ultrasound machine is stationary therefore the user must constantly shift the visual focus between the procedure site and the ultrasound screen. Even slight movements or quick shifting of visual focus can sometimes cause less experienced providers to lose their anatomical landmarks momentarily.[3]

This study included 40 emergency medicine students and residents from a local Level I trauma teaching facility that catered to, on average, 65,000 patients annually. Each participant was asked to complete a pre-exercise survey that determined each provider level of expertise familiarity with the wearable smart technology and included how many landmark-guided and ultrasound-guided central-line placements they had performed on both mannequins and live patients.[3] Many participants were novices and not yet proficient in successfully cannulating a

targeted vessel. The most skilled participants had only performed 28 central lines on live patients and 18 central lines on simulated patients.[3] Therefore, participants were also asked to watch a video demonstrating the use of the smart glass technology and how to cannulate the internal jugular artery under ultrasound guidance appropriately.[3]

Participants were randomly allocated into two groups: the Google glass group and the non-glass group.[3] The study sample consisted of five first-year medical students (MS1), five fourth-year medical students (MS4), five postgraduate year 1 (PGY1) residents, and five postgraduate year 3 (PGY3) residents assigned to the Google Glass group. Five first-year medical students (MS1), five fourth-year medical students (MS4), five PGY1 residents, and five postgraduate year 3 (PGY3) residents were assigned to the non-glass group. The participants randomized into the non-glass group were instructed to establish an internal jugular central line access using an ultrasound machine.[3] Each participant performed an internal jugular vein cannulation first via the short-axis approach and again in the long-axis approach.[3]

The setup for the google-glass group was the same as the non-glass group, except the google glass group wore the google-glass and were instructed to perform the procedure by visualizing the ultra-sound images displayed on their google glass screen instead of the ultrasound display.[3] Each participant performed an internal jugular vein cannulation using the short-axis approach and the long-axis approach.[3] All procedures from this group were also recorded from two different viewing angles.[3] Following the exercise, the participants completed a short post-exercise survey that assessed their experiences using the Google Glass technology (if applicable), whether the technology facilitated or impaired the procedure, and whether they would use such technology in future medical practice.[3] All video footage was reviewed and analyzed by three independent observers. Statistical analysis was performed to assess for

significance between groups using the nonparametric Mann-Whitney U-Test. A *P*-value was considered significant if <0.05.[3]

At every training level the Google Glass group, took longer to perform the procedure. The increased procedure time reached significance level in the PGY3 (151 s vs. 52 s, $p \leq 0.05$) and MS4 group (197 s vs. 91 s, $p \leq 0.05$). The PGY3 participants spent considerably more time directing their focus on the patient (48 s vs. 23 s, $p \leq 0.05$) and the google glass monitor (103 s vs. 29 s, $p \leq 0.05$) compared to the non-glass group. The google glass wearing participants in the MS1 group compared to the non-glass wears spent considerably more time looking at the monitors (139 s vs. 47 s, $p \leq 0.05$).[3] At every training level all the google glass wearers had significantly fewer head movements, demonstrating that the smart glass technology significantly improves ergonomics.[3] An analysis of the post study survey revealed 75% of the partakers were inexperienced with the augmented reality concept and 60% unfamiliar with wearable technology. % of those randomized to wear Google Glass stated that the device was comfortable. Eighteen percent responded very likely, 35% moderately likely, 35% somewhat likely, 8% not very likely, and 5% not at all likely when asked, "how likely would you be to use ultrasound visualization through Google Glass as opposed to traditional ultra-sound machine monitors?"[3]

Smart glasses improvement for ultrasound-guided peripheral venous access

Smart glasses can provide ultra-sound users with instantaneous images. Successfully securing pediatric venous access is sometime challenging because children are often uncooperative, and their veins are usually narrow, thin, and run deeply. Still, for varying clinical purposes, including administration of intravenous drugs and blood sampling, obtaining venous access is crucial and sometimes lifesaving In real-time, ultrasound technology helps healthcare providers cannulate a targeted vessel during venous access procedures.[4] Traditionally ultrasound

is performed at the patient's bedside, and usually the provider rotates their head intermittently to verify the image displayed almost instantaneously on the monitor.[4] Theoretically, it is this rotation of the head that disrupts the hand-eye harmonization vital for successful ultra-sound guided cannulation of the peripheral vein.[4] Lim et al,[4] in a prospective, randomized, crossover pilot study, assessed the efficacy of SG in obtaining peripheral venous access among pediatric patients via ultrasound technology.[4]

The study was conducted in 2018, at a tertiary hospital in Korea stimulation facility. Volunteers for the study were enlisted through emails sent residents in the hospital's emergency department. Twelve male participants with the average age of 32 years volunteered for the study. There were three participants for each grade (PGY2–PGY5). Informed consent was obtained after the primary researchers explained the study's purpose. After which a 2-hour education course on the ultrasound-guided was completed.[4] None of the participants had experience confirming ultrasound images with a SG or were proficient with simulated phantoms, therefore, for at least 30 minutes before participating in the simulation each participant practiced ultrasound-guided venous access with and without SG. For the practice sessions a phantom-simulating adult vessel was used. The real-time ultrasound image was first transmitted from the wireless ultrasound machine to a tablet computer via Wi-Fi, then to the smart glasses. Each participant took part in one of two simulated ultrasound-guided venous access scenarios: with (glasses group) or without (non-glasses group) the use of smart glasses the day following the practice session. Each simulated scenario was video recorded. All ultrasound-guided venous access procedures were performed using a short-axis approach. A researcher directed the simulated scenario and successful venous access was expressed as blood aspiration from a 10-mL syringe attached to the 20-gauge needle. The order of each participant's scenarios was

determined by a randomization process implemented by the investigators. The outcomes were objectively measured by a researcher blinded to the study by reviewing the video recordings. The primary outcome was the procedure time in seconds. Procedure time was described as the time the ultrasound probe contacts the phantom to the time positive aspiration is obtained. Secondary outcomes included the number of skin punctures, the number of head movements and needle redirections until successful venous access was obtained. The visual analog scale (VAS) from 0 to 100, 0 being the easiest and 100 being the hardest was used to measure subjective difficulty of the procedure. After each simulation scenario the volunteers conveyed their subjective difficulty ratings. Mann-Whitney U-tests were used to compare outcomes. Interquartile ranges (IQRs) and medians were used to describe outcome variables. IBM SPSS Statistics ver. 21 was used for statistical analysis, and P-values <0.05 were considered statistically significant. Between the glasses and non-glasses groups no significant difference was noted in procedure time, the number of needle redirections or skin punctures. Yet, the number of head movements was considerably greater in the non-glasses group than in the glasses group. Volunteers in the glasses group reported greater subjective difficulty on the VAS than those in the non-glasses group, non-glasses group: median VAS, 15; IQR, 0 to 30; glasses group: median VAS, 30; IQR, 20 to 65; P=0.04.

Decrease procedure time and improve ergonomics in regional anesthesia

Ultrasonography is progressively becoming a standard of practice in regional anesthesia. Anesthesia providers who use ultrasound machines when performing regional blocks must be profoundly knowledgeable of the anatomical landmarks and be able to keenly correlate the needle position, the position of the ultrasound probe on the patient, and the ultrasound display.[5] Conventionally the provider must intermittently look between the ultrasound display and the

patient. This requires extra head rotations, increasing the time and complexity of the procedure.

Przkora et al,[5] in 2021, proposed using the HMD technology to alleviate the need for extra head movements, simultaneously decreasing the overall procedure time.[5] Twenty-four patients scheduled to receive regional anesthesia were randomly assigned to the traditional ultrasound-guided approach or to the HMD, after Institutional Review Board (IRB) approval was secured from the University of Texas Medical Branch.[5] An in-plane approach using a 21-gauge, 50-mm Stimuplex needle with a 30° bevel was used for all regional blocks.[5] Meticulously recorded by an independent observer was the time from the visualization of the target nerve, skin perforation until the target nerve was touched by the of the needle goading the appropriate stimulation. Also recorded were number of adjustments made to the in the US probe to better visualize the target nerve, needle, head flexion, extension, or rotations greater than 45° were noted.[5] Research findings were analyzed and interpreted with a t-test, and $P < .05$ indicated statistical significance.[5] The result of the study indicated that regional anesthesia performed with the HMD was delivered significantly faster than with the conventional ultrasound-guided approach ($P < .05$; mean: 59.08 vs. 175.08 seconds; standard deviation [SD]: 42.46 vs. 171.51). Providers wearing the HMD made significantly less attempts, redirection, and skin punctures ($P < .05$; mean: 1 vs. 1.42 attempts; SD: 0 vs. 0.52) and head movements with the HMD ($P < .05$; mean: 0.83 vs. 4.75 head movements; SD: 0.83 vs. 2.30).[5] There were no substantial differences noted in type of regional anesthesia performed, resident training level or patient demographics.[5]

Similarly, a study by Przkora et al[6] in 2015 also hypothesized that the total procedure time, operator's head and ultrasound probe movements during simulated peripheral nerve blocks using the HMD device could substantially decrease.[6] The study was also conducted at the University of Texas Medical Branch (UTMB), and approval was successfully obtained from the

University's IRB. Twenty consenting participants including 18 residents (CA 1and CA2) and two faculty from the UTMB Department of Anesthesiology was included in the study. Half of the participants were asked to perform the simulated block procedure without the HMD, followed by the procedure with the HMD.[6] In contrast, the other half performed the simulated block procedure first with the HMD, followed by the procedure without the HMD. A total of 40 simulated blocks were performed.[6]

Like the previous study, an in-plane approach with a 21-gauge, 50-mm “stimuplex” needle with a 30º bevel was used to perform the simulated block on a Blue Phantom.[6] One designated observer recorded the number of head and ultrasound movements to recapture visualization of the nerve and/or the needle while another recorded the time the nerve was visualized, to skin puncture until the nerve was touched with the needle tip.[6]

Results were analyzed using a paired t-test, and $P < 0.05$ was regarded as being statistically significant. The study's findings revealed that participants using the HMD were significantly faster at placing the needle to the target nerve in the phantom when compared to those without (P50.001, mean 7.1 vs. 10.9 seconds, SD 3.5 vs. 6.7). Participants wearing the HMD also shifted the ultrasound probe considerably less compared to participants not wearing the device (P 5 0.016, mean 1.4 vs. 2.3 movements, SD 0.9 vs. 1.9). Furthermore, head movements were significantly decreased among the HMD group (P 5 0.0002, mean 1.2 vs. 4 movements, SD 0.8 vs. 2.8). The level of training did not influence the results. The study showed the decreased time and improved ergonomics advantages to using the HMD during ultrasonography validating the device clinical usefulness.[6]

Udani et al,[7] in 2012, also conducted a pilot study that evaluated the feasibility of using head-mounted display technology to improve ergonomics in ultrasound-guided regional

anesthesia in a simulated environment.[7] Two anesthesiologists performed an equal number of ultrasound-guided popliteal-sciatic nerve blocks using the head-mounted display on a porcine hindquarter.[7] Stanford University, where the study took place animal committee approved the study protocol.[7] Of the two anesthesia providers, one was an expert in ultrasound-guided regional anesthesia and performed approximately 1500 ultrasound-guided peripheral nerve blocks.[7] One was a novice who was a first-year anesthesia resident and performed a total of 10 ultrasound-guided popliteal-sciatic nerve blocks.[7] For each procedure, visualization of the sciatic nerve was through the short axis view and transmitted to the left eyepiece of the HMD via a 13–6-MHz linear transducer.[7] Injectate was deposited around the nerve via an 18-gauge Tuohy-tip epidural needle directed in-plane from lateral to medial toward the target nerve. Between procedural attempts, a 5 minutes "wash-out" period was observed to allow previously injected fluid to drain from the open distal end of the popliteal fossa.[7]

Poor ergonomic episodes were measured by an independent investigator; these behaviors include holding the needle in the nondominant hand, an arching torso, and head-turning greater than 45°.[7] For each procedure, the overall block quality was based on the circumferential spread of the injectate around the target nerve.[7] Each attempt was scored as either adequate or inadequate based on the independent investigator's visualization of the fluid within 4 x 4 quadrants surrounding the targeted sciatic nerve.[7] The anesthesia providers also subjectively rated the head-mounted display's difficulty level and image quality. Each practitioner performed 5 of 10 ultrasound-guided sciatic nerve blocks.[7] All 10 procedures were adequately completed and there were no episodes of poor ergonomics noted.[7] Both practitioners stated that the image quality acceptable on the HMD and despite the tethered nature and weight of the HWD neither provider reported and difficulty.[7] The novice provider stated he found the needle control and

hand eye coordination easier with the device and favored wearing it. Both practitioners did mention an initial learning curve associated with using the device, which included training their eye to include the HMD binocular view into their visual field and adjusting the left eyepiece to a comfortable location.[7]

Kasuya et al,[8] 2017 conducted a study in Japan at Tokoyo's Women's Medical University that aimed to assess the practicability of the HMD for ultrasound-guided nerve block.[8] After an explanation of the study's goal was given and written informed consent was obtained, eight experienced anesthesiologists from the University anesthesia department participated, each with individual experience of at least 30 nerve blocks.[8] All eight participants were board-certified anesthesiologists in Japan (male/ female 5/3, age 44.3 ± 8.8 years, with 17.6 ± 8.6 years in practice).[8] The practitioners took turns performing ultrasound-guided nerve block on a phantom simulator both with the HMD and without the HMD. Each method was repeated three times in two different approaches, the standard and the upside-down approach.[8] The most common method used in most peripheral nerve block is the standard approach where the needle is inserted from above the target.[8] Less common is the upside-down approach, where the needle was inserted from below the target.[8] The target nerve was visualized in the short axis view for each procedure. Only when the needle was fully visualized in the in-plane view on the ultrasound image were the practitioners told to advance the needle.[8]

The attempt was deemed as a failure if the provider took longer than 60 seconds or if the needle insertion site was changed.[8] The procedure time was defined as follows; *T*1 denotes the time from placing the ultrasound probe on the skin surface to the initiation of needle insertion. *T*2 is the time from initiation of needle insertion to needle accession of the target, confirmed by aspiration of air with a syringe, and *T*3 is the time the needle was visible on the ultrasound image

during insertion. Fp: fractional percentage of time the needle was visible on the ultrasound image (Fp = $T3/T2 \times 100$).[8] From the recorded videos, laboratory clinicians who were not directly involved in the research determined the length of the procedure, rate of success, and fractional percentages time from the recorded videos. Comparisons were also made between the control and non-control group using the paired *t*-test and chi-squared test; a *p*-value <0.05 was considered statistically significant.[8] The fractional percentage of time the needle was visible on the ultrasound image during insertion toward the target nerve was considered the primary outcome. Secondary outcomes included rate of success and the length of the procedure. A total of 96 procedures were subjected to analysis because all eight participants completed 12 procedures each using 3 blocks, 2 methods and 2 approaches.[8]

The study results revealed that in the standard and upside-down approaches, T2 times were shorter and fractional percentages were significantly higher with the HMD method than without.[8] While not proven statistically, the group that wore the HMD, in both approaches the had a higher success rate.[8] This study showed that time to reach the target and needle visibility using the HMD improved by 20%.[8] This decrease in time and improvement in needle visibility is considered sufficient in enhancing the quality of the performing peripheral nerve blocks.[8]

Smart glasses for radial arterial catheterization in Pediatric patients

Jang et al,[9] in 2021, conducted a prospective, single-blinded, parallel-arm, randomized controlled trial. The study was conducted at a single-site, tertiary teaching children's hospital in the Republic of Korea.[9] The study aimed to evaluate the benefit of SG over the traditional ultrasound screen in pediatric radial arterial catheterization. Written informed consent was obtained from parents or guardians of the children for their participation prior to the surgery.[9] Pediatric patients who were less than 2 years old and scheduled for elective surgery under

general anesthesia who required invasive arterial blood pressure monitoring or blood sampling were included in the study.[9] Excluded from the study were children with unstable vital signs, including arrhythmia and hypotension, peripheral vascular disease, or a recent history of an infected radial artery puncture site.[9] Participants were randomly assigned to either the ultrasound group or the SG group.[9] Computer software generated the group allocations, which were then placed in sealed envelopes.[9] A total of 116 patients were randomized into the smart glasses (n = 58) and control (n = 58) groups.[9] A trained research professional opened each envelope before the induction of general anesthesia.[9] The independent anesthesia provider who assessed and measured the depth and diameter of the radial artery cannulations from the stored images was also blinded to the group allocation.[9] The patient-specific information collected includes age, weight, sex, the American Society of Anesthesiologists physical status classification, and the type of surgery to be performed.[9] After induction of general anesthesia, the ultrasound-guided radial arterial cannulation was performed by one of four pediatric anesthesiologists who had performed more than 100 arterial cannulations in pediatric patients.[9] The long-axis, in-plane technique with a 24-gauge, 0.7-mm × 1.9-cm over-the-needle catheter was used the perform the arterial cannulation.[9] The four anesthesiologists each performed 29 radial artery cannulations, in both the controlled and the SG group respectively.[9]

The first-attempt success rate of radial artery cannulation was considered the primary endpoint.[9] The number of skin punctures until successful cannulation was achieved was regarded as the number of attempts.[9] An invasive blood pressure waveform confirmed successful artery cannulation on the monitor.[9] A 5-point scale was used to evaluate the practitioner's musculoskeletal fatigue during the procedure.[9] Where 5 = best, meaning the procedure was successful with minimal musculoskeletal ache and had appreciably enhancement to the hand-eye

alignment and coordination; 4 = good, the procedure was done with fewer musculoskeletal fatigue and better hand-eye alignment and coordination; 3 = acceptable, the procedure was done with the usual degree of musculoskeletal fatigue; 2 = poor , the procedure was prolonged because of musculoskeletal discomfort or the provider experienced poor hand-eye coordination and alignment; and 1 = worst, the procedure was paused because of musculoskeletal discomfort or it was very hard to obtain hand-eye alignment and coordination.[9]

The primary outcome, the first-attempt success rate of radial artery cannulation, was considerably greater in the SG group than in the control group (87.9% [51 of 58] *vs*. 72.4% [42 of 58]; $P = 0.036$; odds ratio, 2.78; 95% CI, 1.04 to 7.4; absolute risk reduction, −15.5%; 95% CI, −29.8 to −12.8%).[9] The procedure time to the first-attempt success was shorter in the smart glasses group (median, 33 s; interquartile range [interquartile range], 23 to 47 s; range, 10 to 141 s) than in the control group (median, 43 s; interquartile range, 31 to 67 s; range, 17 to 248 s; P=0.007). The second-attempt success rate of the radial artery was higher in the smart glasses group than in the control group (96.6% [56 of 58] *vs*. 81.0% [47 of 58]; $P = 0.008$; odds ratio, 6.6; 95% CI, 1.38 to 31.1; absolute risk reduction, −15.5%; 95% CI, −26.6 to −4.4%). The procedure time to success within the second attempt was shorter in the SG group (median, 35 s; interquartile range, 23 to 56 s; range, 10 to 420 s) than in the control group (median, 50 s; interquartile range, 33 to 99 s; range, 17 to 355 s; $P = 0.012$).The overall procedure time of arterial cannulation was shorter in the SG group (median, 37 s; interquartile range, 24 to 57 s; range, 10 to 547 s) than in the control group (median, 58 s; interquartile range, 39 to 251 s; range, 17 to 981 s; $P < 0.001$).[9] Furthermore, the number of attempts overall was less in the SG group (median, 1; interquartile range, 1 to 1; range, 1 to 3) than in the control group (median, 1; interquartile range, 1 to 2; range, 1 to 5; $P = 0.027$).[9]

The complication rate overall was lower in the SG group than in the control group (5.2% [3 of 58] *vs.* 29.3% [17 of 58]; $P = 0.001$; odds ratio, 0.132; 95% CI, 0.036 to 0.48; absolute risk reduction, 24.1%; 95% CI, 11.1 to 37.2%), including hematoma (3.4% [2 of 58] *vs.* 20.7% [12 of 58]; $P = 0.004$; odds ratio, 0.137; 95% CI, 0.029 to 0.64; absolute risk reduction, 17.2%; 95% CI, 5.8 to 28.7%).[9] Among the two groups, there was no significant difference in depth of the radial artery and the internal diameter before and after cannulation.[9] The positive ergonomic satisfaction scores (5 = best or 4 = good) was higher in the smart glasses group (65.5% [38 of 58] *vs.* 20.7% [12 of 58]; $P < 0.001$; odds ratio, 7.3; 95% CI, 3.16 to 16.8; absolute risk reduction, −44.8%; 95% CI, −60.9 to –28.8%). Kaplan–Meier analysis indicated that the procedure time was shorter in the SG group than in the control group ($P < 0.0001$).[9]

Smart glasses in simulated Neonatal Intubations

For the novice provider, attaining proficiency in neonatal intubation before completing medical training is becoming progressively challenging and may be because of declining intubation opportunities. The inability of the preceptor to also visualize the airway during an intubation attempt further complicates the training process. Dias et al[10] conducted a study in 2021 in which they proposed using augmented reality (AR)-assisted video laryngoscopy glasses to aid the intubation process. The AR glasses amplifies the patient's airway and projects the image directly into the intubator's field of vision.[10] Real-time feedback to the student can be provided by the instructor who can simultaneously view the patient's airway through video streaming.[10] This study, undertaken by Dias et al., investigated whether the overall intubation proficiency of novice providers in a simulation environment can be improved by AR glasses.[10] Neonatal intensive care (NICU) nurses at Duke University Medical Center made up the study population. The NICU nurses were chosen to mimic novice providers who have very limited

hands-on experience with intubating but have theoretical knowledge of the intubation process and the airway anatomy.[10] A baseline questionnaire was given to the volunteers before the commencement of the experiment and one potential participant was excluded, they had previous experience with intubating live patients.[10]

Randomization using a random number generator computer software was used to equally assign the 45 study participants in 1 of 3 intubation modalities: direct laryngoscopy (DL), indirect video laryngoscopy (IVL) and augmented reality video laryngoscopy (ARVL).[10] Each participant completed 5 consecutive intubation attempts on a Life/form Basic Infant CRiSis manikin using a Miller size 1 laryngoscope blade with the camera and adapter unit attached after receiving standardized teaching.[10] Participant in the DL group had no access to video. Participants in the IVL group had access to a live video stream via a local laptop placed on a table to the left of the intubator.[10] Participants in the ARVL group wore smart glasses while performing DL; the video generated was transmitted to the glasses and a local tablet accessed by a supervisor.[10] Individualized coaching during all attempts was provided by a supervisor, who could view the video stream in real time while assisting those in the IVL and ARVL groups.[10] Telestration supplemented the verbal coaching for the ARVL group, where marks made on a tablet by the supervisor were transmitted in real-time to the smart glasses. A senior neonatology fellow and experienced intubator supervised the participants and provided feedback.[10] The primary outcome of each attempt was recorded as either successful intubation of the trachea within 30 seconds, unsuccessful due to time where the trachea was intubated but within 30 to 60 seconds, unsuccessful due to failure to intubate within 60 seconds, or unsuccessful due to esophageal intubation. A secondary measure involving the time required to intubate separately recorded.[10]

The IL group successfully intubated on 72% of attempts and 70.7% in the AR group *(P*<0.001) compared to the DL group that successfully intubated 32% and placed the ETT in the esophagus on 26% of the attempts, while there were no esophageal intubations in either the AR or IL groups.[10] Additionally, the median time to complete one intubation (successful or otherwise) in the DL group was 35.6 seconds, compared to 21.6 seconds in the IL group and 20.7 seconds in the AR group (p=0.0001). Intubation success of novice providers in a simulation environment, was higher with the use of either IL or AR-assisted video laryngoscopy compared to the standard direct laryngoscopy method.[10] The authors hypothesize that AR may be more efficient than IL in real patients as opposed to the manikins, given the distinctive challenges associated with live patients such as varying unique anatomies, patient movement, oral secretions, and other obstacles that occur during the intubation process.[10]

Similarly, a study conducted by Spencer et al.[11] in 2014 used two case studies to investigate the application of smart glass technology to airway management and assessment. The first case study was about a well 20-year-old male that was involved in a motorcycle accident leading to a gasoline explosion.[11] As a result, the patient subsequently suffered a facial fracture and a 30% total body surface burn.[11] Wound infections and graft failures further complicated his care. Nine months after the initial accident, he was again transported to the hospital with chronic severe pain, cachexia, limb contracture, wound infections, exposed bone, decubitus ulcers, and healed displaced mid-facial fracture.[11] The patient was scheduled for central line placement and wound debridement under general anesthesia.[11] The smart glass was used to record the airway assessment and subsequent tracheal intubation.[11] The patient had a thyromental distance of more than three fingers breadth, good neck extension, malocclusion of the mandible, and limited mouth opening but a grade II Mallampatti view. Upon direct laryngoscopy, with a Miller 2 blade,

a Cormack- Lehane Grade 1 view was obtained. The smart glass recorded the intubation process with no disruption to workflow.[11]

The second case was a 2-year-old pediatric patient scheduled for excision and grafting of burns.[11] The smart glass was used to obtain a grade 1 view on direct laryngoscopy. Other forms of video recording or photography of the intubation process require an additional person and disrupt the care provision.[11] Both case studies show that smart glass technology under standard operating room settings can document anesthetic airway management in real-time with minimal disruption to clinical care.[11]

Preoperative airway assessment can also be done with smart glass as it would be possible to automatically generate an electronic medical record via a secure wireless connection.[11] Preoperative airway assessment traditionally includes assessing thyromental distance, the relationship between the mandibular and maxillary incisors during normal jaw closure and during voluntary protrusion of the mandible, assessing incisor distance, the length of upper incisors, visibility of the uvula, thickness and length of the neck, and range of motion of the head and neck.[11] While the visibility of the uvula and the Mallampati Grade classification can be communicated clearly in writing, some assessment features can be recorded via a video or a photograph and can be wirelessly transmitted to the patient's electronic record.[11] This would be especially useful for patients with abnormal airway anatomy or for those with unique features outside the realm of traditional classification.[11] For example, the patient in the first case study on facial fracture was best communicated through a photograph.[11] Moreover, the Mallampati score could be automatically calculated with facial recognition software and other relevant airway features could also be objectively measured.[11] Automated assessment and visual documentation could revolutionize airway documentation and assessment.[11] A video of the operator's visual

perspective, during the intubation process, can be a powerful adjunct in teaching, self-assessment, and comparing techniques between varying practitioners.[11] The device can also be used for quality control purposes, to record the management of failed and difficult airways.[11]

Kuge et al,[2] highlighted the potential use of smart glass technology as an educational tool. One of the participants of the study, a supervising attending, stated they would talk to the junior anesthesiologists present in the patient room to recommend a more aggressive treatment next time after noticing a gradual trend in decline in the patient's vital functions.[2] Another anesthesiologist said they would have "expected the junior anesthesiologist to call earlier." These examples demonstrate that the supervising attending could potentially use the device to educate the junior anesthetist during a debriefing period.[2]

Smart glass use in vital sign monitoring

Iqbal et al[12] conducted a prospective, observational, and comparative study that aimed to assess the usefulness of the smart glass technology as vital signs monitor in a surgical setting. The study's main purpose is to determine whether the smart glass technology obscures the surgeon's direct or peripheral vision, impedes clinical performance and whether wearing the device increases the surgeon's awareness of patient vital signs.[12]

The study included 37 participants recruited from different medical institutions in the United Kingdom.[12] The volunteers were divided into three groups: novices, intermediates, and experts. The novices included 24 medical students, the intermediates group included 8 urology surgical trainees, and the experts included 5 urology consultants.[12] Before the monitored session, the novices performed a training session followed by a 20-minute laser prostatectomy on the GreenLight Simulator.[12] The experts were consultants who had performed an average of 2000 cystoscopies and 900 laser prostatectomies, and 825 average GreenLight prostatectomies.

The training session was followed by another 20 minutes session using the smart glass to monitor vital signs. Intermediate and expert candidates performed the same procedure but within 10 minutes.[12] The Greenlight Simulator was manipulated to represent events in surgery, such as falling oxygen saturation, blood pressure, and other parameters.[12] All deteriorations were manipulated to occur in the practitioner's presence and with varying times. The monitored sessions had anesthetists and scrub nurses present to simulate scenarios; the session was conducted within a validated full-immersion simulation surgical environment. Participants were asked to complete a quantitative survey upon completion of both sessions.[12] The survey included opinions on the surgical applicability of the smart glass technology.[12] Both scenarios were recorded, and performance was evaluated based on the time taken for participants to respond to abnormal vital signs.[12] To provide objective results, the simulator generated an instant performance evaluation report after the procedure's completion. The overall score was based on task-specific metrics such as blood loss, anatomical structural damage, and average sweep speed. To determine the effect of the smart glass on surgical performance, the previously mentioned parameters were recorded.[12] During both study session the mean heart rate of the practitioner was also recorded.[12] The outcome measures were the time taken to respond to changes in vital signs, the effect of SG on clinical and non-clinical performance evaluated by measuring average heart rate in both sessions, and the feasibility and acceptability of using the smart glass during surgical procedures.[12] Statistical analysis was performed using *GraphPad version 6.0*.[12] The nonparametric Mann-Whitney *U* test was used to compare survey responses among the novices, intermediate and expert candidates in standard monitor and smart glass sessions. A *P*-value of <0.05 was considered statistically significant in both tests.[12] The average response time to abnormal vital signs with a standard vital signs monitor was 51.5 s (95% CI 41.8, 61.25)

compared to 35.5 s (95% CI 24.9, 46.0) with the Google GLASS (P= 0.0267).[12] A substantial proportion (84%) of practitioners responded to abnormal vital signs quicker when performing the simulated operation for the second time using the Google GLASS, with 100% of experts responding faster on the second operation.[12] A highlight of the range of values that were obtained for the standard monitor (Interquartile range [IQR], 13–107 s) compared to the GLASS (IQR 4–115 s).[12] Global simulation score overall for novice was (mean: 177), intermediate (mean: 314), and expert (mean: 420) participants were evaluated, indicating a statistically significant difference between novices and intermediates (P = 0.0038) and novices and experts (P< 0.0001). Global score comparison between intermediates and experts was not statistically significant (P= 0.13).[12] Sweeping is a vital parameter in performing a prostatectomy. During standard monitor sessions, participants had a higher sweeping speed (mean: 7.49 mm/s) than the GLASS session (mean: 7.151 mm/s.[12] Additionally, participants who found the device distracting had higher blood loss during sessions (Range: 0.3–25.7 mL) than those using a standard monitor (Range: 0.4–19.0 mL).[12] Though, notwithstanding, the average blood loss was lower when using the device (mean: 3.66) compared to a normal monitor (mean: 4.16). All parameters of simulation were also noted to be similar in both sessions, including average laser distance from the tissue (P = 0.55), average blood loss (P = 0.76) and average sweep speed (P = 0.59).[12] A total of 45 injuries occurred during the sessions, with injury to the verumontanum occurring most (n = 36). Of these, 12 occurred with the standard monitors and 24 occurred while wearing the smart device.[12] A considerable number of experts (80%), intermediates (75%), novices (79%), stated that the smart device improved vital signs awareness. In contrast, 100% of experts, 75% of intermediates and 71% of novices indicated that they would like to use the glass in another surgical procedure.[12] .

The study by Iqbal et al[12] determined that HMD such as SG are useful in surgery to aid patient care without obstructing the surgeon's view. It is hoped that the innovation and evolution of these devices elicit widespread future application of such devices within the medical field.[12] Liebert et al,[13] in 2016, conducted a randomized controlled trial with a crossover design that investigated the likelihood and prospective value of HMD for wireless real-time wireless vital sign monitoring during surgical procedures requiring conscious sedation in a standardized simulated surgical setting.[13] The study was conducted as part of a residency skills session in the Goodman Surgical Education Center at Stanford University.[13] A total of 14 postgraduate year (PGY)-1 to PGY-5 surgical residents participated in the study.[13] The average age of the study population was 29.7 years, with the level of training ranging from PGY-1 to PGY-5. 64% of the participants were male.[13] Subjects were recruited by e-mail sent to all general surgery residents. Stanford University Institutional review board approved the study and informed consent was obtained from all residents.[13]

Each resident participated in 2 standardized pre-programmed simulation scenarios involving bedside surgical procedures on a high-fidelity computer-controlled mannequin in the simulation center.[13] The mannequin, referred to as SimMan, simulates real-time human physiologic parameters including a palpable pulse, audible cardiopulmonary sounds, blood pressure, oxygen saturation, and respiratory rate.[13] Procedures can be performed on the mannequin, including but not limited to chest tube insertion, virtual bronchoscopies under conscious sedation, and endotracheal intubation.[13] The SimMan 3G software also allows for creating pre-programmed, standardized simulation scenarios.[13] Simulation center staff and 2 study investigators were present in the control room during all scenarios to ensure proper deployment and recording. All scenarios were digitally recorded from two camera angles using.[13]

Participants were randomized to either the experimental or control group for the first scenario.[13] The control group used the conventional bedside monitors to monitor the patient vital functions. Five minutes before the start of the scenario the experimental group received training with Google Glass.[13] The experimental group wore Google Glass with continuous wireless streaming of patient vital signs to the device and the standard bedside vital sign monitor. Subjects in the control group for the first scenario then crossed over to the experimental group for the second scenario, and vice-versa.[13] Therefore, subjects served as a control subject for one scenario and an experimental subject for the other scenario. Immediately following the completion of the scenario's user feedback was collected from the resident via a survey.[13] Two scenarios were used in the study. The selected scenarios represented bedside procedures frequently performed under conscious sedation in the absence of an anesthetist.[13] The first scenario was a left chest tube placement. The first simulated patient was described as a 62-year-old male who was status post a motor vehicle accident.[13] Baseline vital functions were given at the beginning of the scenario, there were preprogramed vital function decline and 2 minutes after the start of the session the patient systolic blood pressure declined from 120 to 58 mmHg. In the second scenario, the simulated patient was a 55-year-old male with liver cancer the in the intensive care unit status post a left hepatectomy.[13] The patient's recovery was complicated by a myocardial infarction. Worsening opacity in the left upper lung field was noted on the morning chest radiography.[13] The residents were directed to use the virtual reality bronchoscopy machine to perform a bedside bronchoscopy. In both scenarios, pre-programmed vital sign deteriorations were timed to occur before the completion of the procedure; the participants were unaware of pre-programmed vital sign deterioration.[13] In scenario one the primary objective outcome was the time taken to recognize the decline in blood pressure and oxygen saturation.[13] The primary outcomes in

scenario two, was the number of glances directed away from the procedural field and towards the vital sign monitor and the recognition of desaturation.[13] Mean and standard deviation were calculated for all continuous variables. User feedback, prior google glass use, gender and PGY-level were reported as percentages.[13] Two observers independently recorded the time it took the residents to recognize the abnormal vital sign, the average time was calculated and used for analysis. The total effect size was calculated as the difference between the group means.[13] The effect size was calculated as Cohen's *d*. student's *t*-test was used to determine whether there was a statistically significant difference in continuous variables between the control and experimental groups. A Chi-square test was performed to assess for statistical significance of the proportions. A *P* value ≤.05 was considered statistically significant.[13]

In scenario one**,** while performing the chest tube insertion, the smart glass group recognized severe hypotension 10.1 seconds earlier than the control group (31.8 and 41.9 seconds, $P > .05$).[13] In the experimental group hypotension was less severe at the time of detection compared with the control group (67.6- and 59.9-mm Hg, $P > .05$); though these findings did not reach statistical significance.[13] The SG group glanced less frequently at the traditional monitors ($P = .04$) and spent 71% ($P = .01$) less time looking away from the procedural field to view the traditional vital sign monitors than the control group.[13] Use of the smart device during the bronchoscopy resulted in 8.8 seconds faster detection of critical desaturation that progressed quickly ventricular tachycardia, compared to the controlled group (64.6 vs. 73.4 seconds, $P > .05$).[13] Similar to findings in scenario 1, the SG group in scenario 2 utilized the traditional vital sign monitors less frequently ($P = .001$) and spent significantly less total time looking away from the procedural field to view the monitor ($P = .003$) compared with the control group.[13]

Following the completion of the study, all 14 participants completed an online survey. Most of the resident, 64% " agreed" or " strongly agreed" that Google Glass increased their situational awareness, 86% stated it aided vital sign monitoring and 93% indicated that the device was easy to use in the bedside procedural setting.[13] Eighty-five percent of the residents believed that the google glass wireless monitoring technology had the potential to improve patient safety.[13] 86% opposed when asked whether the device impeded their ability to perform the bedside procedure. Nonetheless most practitioners did not believe that traditional monitoring could be replaced by the Google Glass technology. Many indicated that they most definitely would consider using Google Glass technology in their future practice. This pilot study adds to mounting research that supports the clinical benefits the smart glass technology.[13]

Smart Technology during General Anesthesia

In 2010, Liu et al[14] conducted a prospective, controlled stimulator-based study. A 2 (display) × 3 (trial) repeated-measures design was used. Six Royal Adelaide Hospital (RAH) anesthesia providers volunteered for the study, and informed consent was obtained from them prior to the commencement of the study.[14] Display is the monitoring technologies available to the study participants, the two “displays” are the standard patient monitor in the control setting, and the HMD device in the experimental group.[14] The three “trial” described the first, second, or third case to be performed by participants for each condition.[14] Each participant provided anesthesia to 6 patients, corresponding to the 6 combinations of the experimental design. The HMD worn by the participants displayed the patient's vital functions including blood pressure, oxygen saturations, respiration rate, pulse rate, heart rate, capnography waveforms end-tidal and inspired CO2, anesthetic agent, mean alveolar concentration (MAC), O2, and N2O.[14]

Approval was obtained from RAH and the University of Queensland Human Research

and Ethics Committee. The study was registered with the Australian New Zealand Clinical Trials Registry.[14] The selection criteria included prior participation in at least 1 simulator-based HMD study conducted at the RAH, regularly being in Urology cases, and being a board-certified attending anesthesiologist.[14] Six dependent variables are included, including the frequency, percentage, and duration of participants' head turns toward the anesthesia workstation and the surgical field. Specific inclusion and exclusion criteria intended to minimize the variability between cases and increase statistical power were used to select cases.[14]

The study was divided into three stages: the orientation, data collection, and debriefing phase. Participants were given an opportunity to use and familiarize themselves with the smart device, informed about the data collection process and completed a background questionnaire in the orientation stage.[14] The study was executed in the data collection stage and participants completed a survey during the debriefing stage.[14] During the data collection phase, participants provided anesthesia with and without the HMD over a 4- to 12-week period. The initial display condition (control versus HMD) was selected randomly and then alternated for every consecutive case.[14] Participants performed no more than 2 cases for the study in 1 day.[14] Differences in the percentage, frequency, and duration metrics from the head-turning data were independently tested using a repeated-measures analysis of variance for each measure with $\alpha = 0.05$, 2-tailed. The factors were display (control, HMD) × trial (first, second, third) × phase (induction [drugs], induction [LMA placement], induction [draping], maintenance, emergence) × gaze location (anesthesia workstation, patient/surgical field).[14] Video recording was collected from 36 cases that ranged from 17 to 75 minutes in duration with an average time of 31 minutes.[14] The frequency of practitioners looks toward the anesthesia workstation and patient/ surgical field and the average duration of each look were calculated from 16,342 head turns coded in 22 hours of

video.[14] Comparison between the controlled and the experimental group revealed that participants with the HMD spent less time looking at the anesthesia workstation (21.0% vs. 25.3%, $P = 0.003$) and more time looking at the surgical field/patient (55.9% vs. 51.5%, $P = 0.014$), than in the control condition.[14] Participants looked more frequently toward the patient/surgical field (5.0 head turns/min) than the anesthesia workstation (3.9 head turns/min). On average, participants looked at the surgical field for 7.2 seconds per head turn and looked at the anesthesia workstation for 3.7 seconds per head turn.[14]

Participants rated the standard patient monitor as less useful when using the HMD (5.2 vs. 6.2, $P = 0.030$). However, on a Likert scale from 1 (useless) to 7 (very useful), participants rated the HMD as being moderately useful (5.4 vs. neutrality at 4.0, $P = 0.013$). There was a tendency toward rating the HMD as comfortable to read (4.9 vs. neutrality at 4.0, $P = 0.085$) and easy to monitor (5.1, $P = 0.065$), which did not reach significance with this sample size. The responses to post-experiment questionnaires were not significantly different from neutral (4.0), indicating that participants did not have significant positive or negative views about the HMD.[14] In questionnaire free-form responses, participants indicated that they liked that vital sign monitoring with the HMD could be done from anywhere in the operating room without turning around but disliked wearing the bulky experimental equipment.[14] In conclusion, the study found that wearing the HMD to monitor a patient's vital function increases the time the anesthetist spending directly monitoring the patient and providing pertinent patient care.

Google glass monitoring in pediatric cases

In 2016 Drake-Brockman et al[15] conducted a pilot study to assess the google glass acceptance as a patient monitoring device in pediatric anesthesia. The study was classified as a quality-of-care audit.[15] Trainee anesthetists and consultants at Princess Margaret Hospital, Perth,

Australia, were opportunistically sampled and invited to participate in the study.[15] A total of 40 anesthetists participated, and of which 10 (25.0%) were registrars in year 3 and 4 of their anesthesia training, 7 (17.5%) were fellows, senior registrars in the final year of the anesthesia training, qualified anesthetists performing an additional pediatric anesthesia fellowship, or overseas- trained medical specialists, and 23 (57.5%) were pediatric anesthesia consultants. Patient consents were waived as the additional device did not change patient monitoring.[15]

Each provider completed 1-4 cases the average number being 2. Both scheduled and emergency cases were included in the study, but majority of the cases were plastics, general surgical, orthopedics and ear–nose–throat procedures.[15] During the procedure, the procedure details were meticulously recorded including any comments made by the anesthetist regarding the ease of use and comfort of the device and any issues arising from the device.[15] After the completion of the case the anesthesia providers were asked to complete a questionnaire. The questionnaire consisted of Likert scale responses and included opinions regarding the device's contribution to patient management, comfort level of the device, willingness to recommend the device to colleagues and use the device again.[15]

Analysis of the study's results revealed that there was no statistically significance between trainee and consultant anesthetists regarding the questions 'I would use the device again' ($P = 1$) or 'I would recommend the device to a colleague' ($P = 1$). Consultants however were more optimistic when asked if the device improved patient management' than fellows or registrars ($P = 0.43$). Most anesthetists, 90% agreed that the device was comfortable to wear. Consultants had the least difficulty reading the information on the device ($P = 0.64$).[15] Ironically, they were also least likely to agree that they 'would wear the device in view of the patients' ($P = 0.10$).[15]

In previous studies, HMDs were criticized for being uncomfortable, bulky, and challenging to wear. However, the Google Glass, does not appear to suffer from this issue, as 90% of anesthetists indicated that the device was comfortable and 86% found the device easy to read.[15] Several users found the device clinically helpful, with anesthetists noting that the device improved patient management in eight cases.[15] Furthermore, 78% of the anesthetist indicated that they would consider using the device again, and 58% reported that they would recommend the device to a colleague.[15]

Summary of Evidence

The Smart Glass is a head- mounted display platform that allows users access to an array of digital media and functions, while performing a variety of daily tasks. In the clinical setting, an interface between the smart device and existing traditional patient monitoring devices holds the potential to provide clinical practitioners real- time access to resourceful data such as patient vital signs for improved situational awareness. The literature reviewed discussed SG use as an adjunct to patient monitoring and the performance of procedural tasks during the perioperative period. Iqbal and Liebert concluded that SG improve intraoperative patient vital signs monitoring and decrease time looking away from the procedural field, causing earlier recognition of patient deterioration.

Schlosser et al and Kuge et al investigated how supervising anesthesiologists could benefit from using head-worn device (HWD) in monitoring multiple patients; and found that the HWD increase the supervising anesthesiologist's awareness. Almost 50% of the literature evaluated smart technology application to procedural tasks and regional anesthetic techniques found that SG wearers had significantly fewer head movements, demonstrating that the SG technology significantly improves ergonomics. Jang et al in 2021 found that using SG improved

the first-attempt success rate of radial artery cannulation, decreasing overall procedure time. Dias et al postulated that augmented reality glasses could improve successful first-time intubations, while Spencer et al cited that the new technology could revolutionize airway assessment and management. Future efforts should focus on reducing mental workload when supervising anesthesiologists monitor multiple patients with a SG, comfort, battery life, and the effects of long-term wearability.

Conclusion

All the literature reviewed determined that SG could improve perioperative patient management. The studies conclude that there are several applications of SG technology in the field of anesthesia. Vital sign streaming with SG or similar platforms is feasible and may enhance procedural situational awareness. The provider can wirelessly transmit assessment data to the attending, providing flexibility and increasing efficient informed remote decision making. The SG increases the first-time intubation success, documents airway assessment, and captures more comprehensive data. The SG assist in ultrasound-guided cannulation of an artery or central vein as it gives the user a direct view of the ultrasound machine without the user having to shift the head or change their view. The glasses enable users to share what they see with people and other users in other physical places. The SG improves US-guided regional anesthetic blocks first-attempt success rate, provider ergonomic, reduced first-attempt procedure time, and decreased overall complication rates.

Rationale

The literature reviewed and presented adds to the growing body of literature of potential applications of the smart device in the medical setting and provides evidence for the feasibility and potential utility of wireless streaming device in monitoring patient's vital signs, aiding

intubations and documenting airway assessments.[13] Based on the results, there is also sufficient ergonomic and time advantages to using an smart device for ultrasound-guided needle placement and procedural tasks to validate this observation and identify the smart glass as an useful device in the perioperative period. If the presentation of this inclusive research positively influences anesthesia provider attitudes and increases knowledge respectively, there is the possibility for its application in current anesthesia practice to increase patient safety and to decrease medical and human errors while performing procedural tasks in the perioperative period.

Objectives

DNP Project Goals

The provision of anesthesia often takes place in a complex care environment where the patient's safety is contingent on the competence, dedication, and reliability of the anesthesia provider and the technology employed.[16] Anesthesia is constantly evolving, and new technological development is at the forefront of the process.[17] The smart glasses have been suggested to improve patient care and safety in the complex anesthesia realm because the technology affords the provider mobility, judicious access to information, and hands-free interaction.[17] Smart glasses are a new intelligent eyewear device with various functions through software installation and host an independent operating system like a smartphone. The potential of this new wearable intelligent technology is astounding; the device is portable, easy to use, and straightforward.[14]

Research also shows that the innovative glass technology can aid novices in successfully securing an airway and assist in ultrasound-guided cannulation of an artery or central vein as it gives the user a direct view of the ultrasound machine without the user having to shift the head or change their view. The glasses also enable users to share what they see with people and other

users in other physical places. For example, a nurse anesthetist can wirelessly communicate assessment data in real time to a responsible anesthesiologist, even if they are in another location. In addition to more informed remotely made decisions, it provides flexibility. Medical doctors or other skilled practitioners do not need to come to the room. This creates the potential for both faster and better decisions. This benefits both the work environment and improves patient safety. This Quality Improvement Project aims to improve anesthesia provider vigilance, decrease anesthesia-related complications, and ensure that each patient has a safer surgical anesthetic experience.

SMART Goals and Outcome

To formulate goals and objectives, the SMART framework was used. The SMART framework entails utilizing specific, measurable, achievable, realistic, and timely objectives.

Specific

Anesthesia providers will have a voice over power point education module on using the smart glass technology as an adjunct in the surgical setting when intubating, monitoring vital patient functions, performing regional blocks, and aiding ultrasound-guided central and arterial line placement.

Measurable

The usefulness of the smart glass technology will be evaluated via the analysis of a questionnaire that will be provided to recipients before and after the delivery of the educational intervention. Outcomes will be calculated by evaluating the anesthesia provider's knowledge of the benefits and usefulness of the smart glass technology. Qualtrics software will be utilized to synthesize the data and generate the results.

Achievable

Anesthesiologists and Certified Registered Nurse Anesthetists (CRNAs) in a affiliated hospital system will provide a sufficient sample size to generate finding indicating whether learning has occurred concerning the advantages of the smart glass technology during the provision of anesthesia care. The finding will also provide an insight into the Anesthesia professional's attitude towards the new technology and willingness to implement the new technology into practice.

Realistic

Anesthesia providers will be educated on the suggested utilization of the smart glass technology during patient monitoring or while performing routine anesthetic procedures by the leader of this education initiative.

Timely

Over six months, the primary investigator will collect data, analyze findings, and disseminate statistically significant results. The anesthesia providers will be allotted four weeks to participate in the QI project. Pertinent outcomes of this QI project will showcase the quality of the educational module teaching that focuses on the smart glass technology's benefits during anesthesia provision and the likelihood of the anesthesia providers implementing the new technology into practice.

Program Structure

The identification of pertinent stakeholders, their involvement, and support are imperative to the success of this educational module in improving the knowledge and attitudes among anesthesia providers. Stakeholder awareness and involvement are critical components of

successfully translating the education module into clinical practice. The participation of stakeholders would better facilitate the promotion of smart glasses as a beneficial adjunct during the provision of anesthesia.[18] The utilization of the SWOT assessment tool aids in the identification of the **s**trengths and **w**eaknesses in the organization concerning the project, the **o**pportunities inherent in the work of the project, and any potential **t**hreats to project success. The SWOT is most effective in an open dialogue with key stakeholders and customers.[18] The project team uses the SWOT analysis to develop strategies to exploit strengths, compensate for weaknesses, capitalize on opportunities, mitigate threats, and communicate essential information to those affected by the work of the project. Translation will be most effective when its execution is carefully planned with full consideration of the people, resources, culture, and history of the organization into which it is introduced.[18]

Strengths and Opportunities

The smart glass technology is an influential tool that can significantly improve patient safety by increasing access to patient-related information and aid healthcare professionals in their struggle to gain situational control during anesthesia care.[16] The smart glass technology allows the patient's vital signs to be within the anesthesia provider's visual field regardless of the ongoing task or their head orientation, thereby reducing the scanning frequency between the anesthesia workstation and the patient.[16] Ideally, the anesthetist could devote more time to monitoring the surgical field and, ultimately, the patient, thus improving patient care. Furthermore, the anesthesiologist would not need to re-accommodate their eyes as often if the vital sign's imagery on the HMD were presented at the same optical distance as their ongoing task. The smart glasses technology can also significantly alter regional anesthesia and ultrasound-guided central and arterial line cannulation as a replica of the ultrasound screen image

is displayed in front of the anesthetist's eyes, so the operator can easily see both the procedure field and the ultrasound screen simultaneously without any head and eye movement. The potential impact of head-mounted display devices on the overall success and improvement of provider ergonomics in anesthetic care during technically complex procedures is astounding.

Opportunities

Although several commercial websites describe the use of smart glasses in a surgical environment, the number of scientific studies is limited. A systematic review of wearable technology, including smart glasses, in the OR concludes that in several intraoperative specialties, wearable technology has the potential to improve safety, communication, and education. A recently published scoping review highlights both benefits and limitations related to healthcare professionals' use of smart glasses in situations occurring in anesthesia care. Evaluation of a head-mounted display that visualizes VS for anesthesiologists during general anesthesia prompted the conclusion that more research is needed to determine what information should be displayed and whether a head-mounted display can improve the anesthesiologists' performance.

Threats and Weakness

The average cost of the head-mounted display glasses is approximately $800. This is a small amount of money, but multiplied times every anesthetizing site, the expense rises. To effectively operate the technology, a constant and reliable Bluetooth connection between the electronic monitor and the smart glass is required. Many anesthesia providers in previous studies voiced concerns regarding the weight of the smart device. The usual eyeglasses are 25 – 50 grams or 0.05 – 0.1 pounds; meanwhile, the average smart glass is 119 grams, or 0.43 pounds, making it approximately 4 – 8 times heavier. Problems may also arise if the anesthesia provider

wears prescription glasses, as now it is cumbersome and uncomfortable to wear two pairs of glasses simultaneously. The use of smart glass technology for routine vital signs monitoring would indeed be a large market if adopted into widespread practice. However, would the addition of smart glasses for routine monitoring be an overdose of technology in the operating room? Does excessive technology distract us from the actual patient?[2]

Organizational Factors

Implementing the smart glass technology for patients undergoing anesthetic procedures during the perioperative period quality improvement project will be conducted as a collaborative effort amongst the appropriate disciplines. The support and benefaction of the organization's anesthetic team are crucial to the quality improvement project's success. The participating anesthetic team can provide a reservoir of pertinent information critical to evaluating the efficacy of the educational module presented. Visual depictions that correlate with the appropriate literature hypothesizing that smart glass technology will significantly improve anesthetic tasks and procedures via diagrams will be utilized. In addition, Anesthesia providers will receive identical questionnaires pre- and post-educational voice over PowerPoint presentations that assess their knowledge and attitudes toward implementing new technology before and after the educational module. To evaluate the success of the educational presentation, both results will be compared via data analysis. The data analysis is critical in assessing the educational module, understanding the study, and assessing how the QI project goals aligned with the project's findings. Components to be reviewed include the PICO question, background information, methods, results, limitations, opportunities, and conclusion.

Conceptual Underpinning and Theoretical Framework

Several theoretical frameworks exist based on the effective introduction of innovations in health care. However, most models originate from Rogers's Diffusion of Innovations theory, in which he describes the process by which an innovation is communicated through specific channels over time among the members of a social system".[19] The theory was developed by Everett in the 1930s, Everett defined an innovation as "an idea, practice, or objective perceived as new by an individual, a group, or an organization."[19] Some amount of variation exists among the different theories, but all models essentially follow a similar planning sequence: (1) to maximize success, the innovations are systematically introduced, and (2) a planned innovation strategy should be tailored to the determinants that facilitate or impede the intended innovation process.[20] The time portion includes knowledge, persuasion, decision, implementation, and confirmation stages as individuals adopt the innovation. Rogers described these stages at the individual level; recent research in the hospital environment has confirmed similar stages at the organizational level.[19] The present quality improvement study assesses the new innovative smart glass technology implementation during the intraoperative provision of anesthesia.

Methodology

Settings and Participants

The quality improvement study will occur at a level one trauma center in Southwest, FL. The primary study participants will include Anesthesiologists, Anesthesia Assistants (AAs) and Certified Registered Nurse Anesthesiologists (CRNAs). The participants will be voluntarily recruited via an anonymous email link. The anticipated sample size will be approximately 5-15 anesthesia providers.

Description of Approach and Project Procedures

The primary objective of the quality improvement project is to administer an online

educational module to anesthesia providers that focus on the significant benefits of the smart glass technology during the provision of anesthesia. In the first phase of this project, an online pre-test will be administered to assess the anesthesia providers' baseline knowledge and attitudes toward adopting new technology. The second phase will include the presentation of a PowerPoint to the anesthesia providers. This will be the primary means of educating and exhibiting the benefits of the smart glass technology and its various applications to the anesthesia profession and improving patient safety. The third phase will include a post-educational module assessment that will evaluate the knowledge gained from the successful completion of the educational module presented and assess any shifts in attitudes and willingness to adopt the new technology into practice. The results of the pr-test and post-educational module test will also gauge the efficacy of the education provided.

Protection of Human Rights.

Initial project approval from Florida International University (FIU) Institutional Review Board (IRB) will be obtained prior to the launch of this educational module quality improvement project. The recruitment population for this study is limited to Anesthesiologists, Anesthesia Assistants and CRNAs. Recruitment will be done through a Qualtrics link that will be sent via electronic mail, participation will be voluntary and anonymous, and there is no penalty for withdrawing or refusing to participate. However, participating anesthesia providers will benefit from the exposure to the new technology and increase knowledge and attitudes toward the advantages of utilizing the innovative device during the perioperative period. The risk associated with this quality improvement project is minor, mainly the time these diligent professionals need to complete the project.

Data Collection

For this quality improvement project, the primary tool that will be used to evaluate the efficacy of the educational module will be the pre and post-test. Qualtrics will be used to send identical, anonymous questions in a survey format. The questions will inquire about previous knowledge of the smart glass technology, attitudes towards new equipment and devices, and willingness and likeness to adopt the new technology into practice after the education has been administered. Though the questionnaire will be anonymous, specific data will be collected, including the participant's title, whether anesthesiologist or CRNA, ethnicity, age, gender, and years of experience. The survey will consist of 10 questions focusing primarily on the basic understanding of the new innovative technology and the potential benefits for anesthesia providers. The pre-test survey will assess baseline knowledge and attitudes; the post-test will assess what was learned, the overall efficacy of the educational module, and the willingness to adopt the new technology into everyday practice. Collected data will be confidential, and no subject identifiers will be recorded during any component of the QI project.

Data Management and Analysis Plan

The DNP student will be the primary investigator of this project and will be responsible for disseminating and implementing the surveys. All data will be kept in a secure file on a password-protected database and will only be accessible by the primary investigator and the DNP project advisor. There will be no record of the participant's identifiers to protect confidentiality. Statistical analysis of both the pre and post-test will be done to assess the efficacy of the intervention.

Results

Pre-Test Demographics

The pre-test demographics are displayed in Table 1, shown below.

Table 1. Pre-Test Participants Demographics

Demographic	**n (%)**
Total Participants	5 (100.00%)
Age	
25-34	3 (60.00%)
35-44	1 (20.00%)
45-54	1 (20.00%)
55-64	0 (0.00%)
65+	0 (0.00%)
Gender	
Male	2 (40.00%)
Female	3 (60.00%)
Ethnicity	
African American	1 (20.00%)
Caucasian	2 (40.00%)
Hispanic	1 (20.00%)
Other	1 (20.00%)
Medical Profession	
CRNA	5 (100.00%)
AA	0 (0.00%)
Anesthesiologist	0 (0.00%)
Other	0 (0.00%)
Highest Education	
Associate's degree	0 (0.00%)
Bachelor's degree	0 (0.00%)
Master's degree	0 (0.00%)
Doctoral degree	5 (100.00%)
Experience	
Less than 1 year	2 (40.00%)
1 to 2 years	2 (40.00%)
2 to 5 years	0 (0.00%)

5 to 10 years	0 (0.00%)
More than 10 years	1 (20.00%)

There were five participants in the pre-test demographics, and all completed the pre-test survey. Most of the participants were female (n=3, 60.00%), as opposed to male (n=2, 40.00%). There were also a range of ethnicities represented: African American (n=1, 20.00%), Caucasian (n=2, 40.00%), Hispanic (n=1, 20.00%), and other (n=1, 20.00%). Information was obtained regarding the participant's role at the hospital, and it was found that all participants were Certified Registered Nurse Anesthetists (CRNAs) (n=5, 100%). The participants were questioned about the length of time practicing, finding that the practice period ranged: less than one year (n=2, 40.00%), 1 to 2 years (n=2, 20.00%), 2 to 5 years (n=0, 0%), 5 to 10 years (n=0, 0%), and more than 10 years (n=1, 20.00%).

Pre-Test Adverse Events During Anesthesia Knowledge

All five participants (100.00%) admitted that their view of the traditional patient monitor have been obscured during the administration of anesthesia because of surgical positioning or the configuration of the procedure room. Majority of the participants (80.00%) were unaware of the percentage of alarms in the critical care environment that have been reported as false positives, potentially leading to clinicians becoming dangerously desensitized. Prior to the implementation of the educational intervention none of the participants (0.00%) knew the incidence of anesthesia-related adverse events during the administration of anesthesia.

Pre-Test Smart Glass Technology Knowledge

Pre-test knowledge of the smart glass technology showed that only one participant (20.00%) was aware of the existence of the technology prior to participating in the study, while four participant (80.00%) had no prior knowledge of the technology. Although all participants (100.00%) were able to correctly deduce the correct definition of the smart glass device which

include a hands-free device that is worn like a regular pair of eyeglasses mounted on the head but unlike regular eyeglasses the smart glass displays patient information in the user's field of view in real-time. Before the educational intervention two participants (40.00%) presumed that the smart technology would only aid intraoperative vital sign monitoring, while most of the participants (n=3, 60.00%) correctly predicted that the technology could also be utilized not only in intra-operative vital sign monitoring but also in multi-patient monitoring and ultra-sound guided procedures regional techniques, arterial cannulations, and central line placements. When asked whether the smart glass technology could be used as a tool to aid intubations, most participants (n=4, 80.00%) selected the correct answer.

Pre-Test Utilization and Attitudes of the Smart Glass Device

Before the educational intervention, most participants (n=3, 60%) revealed that the benefits of the smart technology to the anesthesia provider included improved situational awareness, ergonomics, and vital signs monitoring. While one participant (20.00%) believed the device benefits were limited only to vital signs monitoring, another participant (20.00%) stated the device might prove beneficial only in improving the provider's ergonomics. Therefore, not surprisingly, the attitudes towards using the smart glass device would be high if the technology were available for clinical use at their employment facility. Two participants (40.00%) were extremely likely, another two participants somewhat likely (40.00%), and one participant (20.00%) extremely unlikely to use the smart glass technology. When asked in what way would the smart glass technology be most beneficial to them, most participants (n=4, 80%) stated that the smart glass technology would be most beneficial for intraoperative vital sign monitoring. In comparison, one participant (20.00%) stated that they would use the device not only for

intraoperative vital signs monitoring but also during ultra-sound guided regional anesthesia and placement of central and arterial lines.

Post-Test Demographics

Table 2 (see below) shows the post-test demographics.

Table 2. ***Post-Test Participant Demographics***

Demographic	**n (%)**
Total Participants	5 (100.00%)
Age	
25-34	3 (60.00%)
35-44	1 (20.00%)
45-54	1 (20.00%)
55-64	0 (0.00%)
65+	0 (0.00%)
Gender	
Male	2 (40.00%)
Female	3 (60.00%)
Ethnicity	
African American	1 (20.00%)
Caucasian	2 (40.00%)
Hispanic	1 (20.00%)
Other	1 (20.00%)
Medical Profession	
CRNA	5 (100.00%)
AA	0 (0.00%)
Anesthesiologist	0 (0.00%)
Other	0 (0.00%)
Highest Education	
Associate's degree	0 (0.00%)
Bachelor's degree	0 (0.00%)
Master's degree	0 (0.00%)
Doctoral degree	5 (100.00%)

Experience	
Less than 1 year	2 (40.00%)
1 to 2 years	2 (40.00%)
2 to 5 years	0 (0.00%)
5 to 10 years	0 (0.00%)
More than 10 years	1 (20.00%)

There were five participants in the post-test demographics, and all completed the survey. Most participants were female (n=3, 60.00%), as opposed to male (n=2, 40.00%). There was also a range of ethnicities represented: African American (n=1, 20.00%), Caucasian (n=2, 40.00%), Hispanic (n=1, 20.00%), and other (n=1, 20.00%). Information was obtained regarding the participant's role at the hospital, and it was found that all participants were Certified Registered Nurse Anesthetists (CRNAs) (n=5, 100%). The participants were questioned about the length of time practicing, finding that the practice period ranged: less than one year (n=2, 40.00%), 1 to 2 years (n=2, 40.00%), 2 to 5 years (n=0, 0%), 5 to 10 years (n=0, 0%) and more than 10 years (n=1, 20.00%).

Post-Test Adverse Events During Anesthesia Knowledge

In the pre-test, all five participants (100.00%) admitted that their view of the traditional patient monitor had been obscured during the administration of anesthesia because of surgical positioning or the configuration of the procedure room. After the educational module, anesthesia provider knowledge on the incidence of false positive alarms in the critical care environment leading to clinicians becoming dangerously desensitized, improved. Most participants (n=3, 60.00%) were aware that the incidence of false positives was as high as 90%. Therefore, a minority of participants (n=2, 40.00%) were unaware of the clinical incidence of false positive alarms in critical care environments. When asked about the approximations of preventable

anesthesia-related adverse events, the correct answer of 50-60% was selected by four participants (80%), while an incorrect answer (20-30%) was chosen by one participant (20%). There was an increase in the knowledge of adverse anesthesia-related events. Adverse anesthesia-related events knowledge improvement was noted for all questions. Table 3 shows the differences in responses from the pre- to post-test.

Table 3. ***Adverse Events During Anesthesia Knowledge Pre- and Post-Test***

Question	Correct in Pre-test	Correct in Post-test	Difference
Up to what percentage of alarms in the critical care environment have been reported as false positives, potentially leading clinicians to become dangerously desensitized?	20.00%	60.00%	20.00%
Approximations of preventable anesthesia-related adverse events range between?	0%	80.00%	80.00%

Post-Test Smart Glass Technology Knowledge

In the pre-test, all participants (n=5, 100.00%) were able to correctly determine the correct definition of the smart glass device, which includes a hands-free device that is worn like a regular pair of eyeglasses mounted on the head, but unlike regular eyeglasses, the smart glass displays patient information in the user's field of view in real-time, but surprisingly in the post-test only 4 participants (80%) were able to define the smart-glass technology correctly. Nonetheless, anesthesia provider knowledge of smart glass technology improved overall after the educational module. In the pre-test, 40% of the participants believed that the smart technology could only be used for intraoperative vital signs monitoring. This number decreased to 20% in the post-test. In the post-test, most participants (n=4, 80%) knew that in addition to

intraoperative vital signs monitoring, the smart glass could also be used for multi-patient monitoring, ultra-sound guided regional procedures, and ultra-sound guided central line and arterial line placements. All participants (n=5, 100.0%) knew the smart technology could be used as a tool to aid intubations compared to 80% in the pre-test. When asked in the post-test the benefits of the smart technology to the anesthesia provider, four participants (80%) were able to correctly identify the correct answers, which included: improved situational awareness, ergonomics, and intraoperative vital signs monitoring compared to only 60% of participants in the pre-test. A knowledge improvement was noted in most questions regarding knowledge and use of the smart technology during the provision of anesthesia. Table 4 shows the differences in responses from the pre- to post-test.

Table 4. ***Smart Glass Technology Knowledge Pre- and Post-Test***

Question	**Correct in Pre-test**	**Correct in Post-test**	**Difference**
Which statement is true of the smart glass technology? a. A device that affords the user easy access to patient information, mobility, and hands-free interaction. b. A device that is worn like a regular pair of eyeglasses mounted on the head, but unlike regular glasses, the SG displays information in the user's field of view through a prism in real-time. c. The use of SG by the anesthesia provider during procedures decreasing head and eye shifting from the patient to the monitors, thus improving the anesthesia provider ergonomics. d. All the above	100.00%	80.00%	-20.00%
Smart glass technology can be used for: a. Intraoperative vital sign monitoring b. Multi-patient monitoring	60.00%	80.00%	20.00%

c. Ultrasound guided: Regional anesthesia, arterial cannulation, or central line placement d. All the above			
The smart glass can be used as a tool to aid intubation: True or False	80.00%	100.00%	20.00%

Post-Test Utilization and Attitudes of Smart Glass Device

Attitudes towards the benefit of the smart glass to the anesthesia provider improved after the educational intervention, with 4 participants (80%) stating that the smart glass can improve situational awareness, ergonomics, and intraoperative vital signs monitoring for the anesthetist, which increased from 60% in the pretest. After the educational module, the presumed personal benefits of the device to the participant also increased, with three (60%) participants now stating that they would use the device not only for intraoperative vital signs monitoring but also in ultra-sound guided regional techniques and arterial and central line placements. The inclination to implement the smart glass technology was high after the educational module intervention. Three participants (60%) stated that they were extremely likely to use the new technology if it were available for use at their place of employment, and two participants (40.00%) stated that they were neither likely nor unlikely to use the technology if it were available today for use. No negative or very negative attitudes were expressed regarding the use of the new technology in clinical practice after the educational module. Table 5 shows the differences in responses from the pre- to post-test.

Table 5. ***Utilization and Attitudes of Smart Glass Device Pre- and Post-Test***

Question	**Pre-test**	**Post-test**	**Difference**
Benefits of the smart technology for the anesthesia provide:		0.00%	0.00%

Improved situational awareness	0%	0.00%	-20.00%
Improved ergonomics	20.00%	20.00%	0.00%
Improved Vital Signs Monitoring	20.00%	80.00%	20.00%
All the Above	60.00%		
In what way would the Smart Glass technology be MOST beneficial to you:			
Intra-operative VS monitoring	80.00%	40.00%	-40.00%
Multi-patient monitoring	0.00%	0.00%	0.00%
Ultra-sound guided: Regional anesthesia,	33.33%	80.00%	46.67%
Arterial cannulation, or central line placement	0.00%%	0.00%	0.00%
All the Above	20.00%	60.00%	40.00%
If the smart glass technology was available for use at your hospital today, how likely are you to use the new technology?			
Extremely Likely	40.00%	60.00%	20.00%
Somewhat Likely	40.00%	0.00%	-40.00%
Neither Likely nor Unlikely	0.00%	40.00%	40.00%
Somewhat Unlikely	0.00%	0.00%	0.00%
Most Unlikely	0.00%	0.00%	0.00%
Extremely Unlikely	20.00%	0.00%	-20.00%

Discussion

Limitations

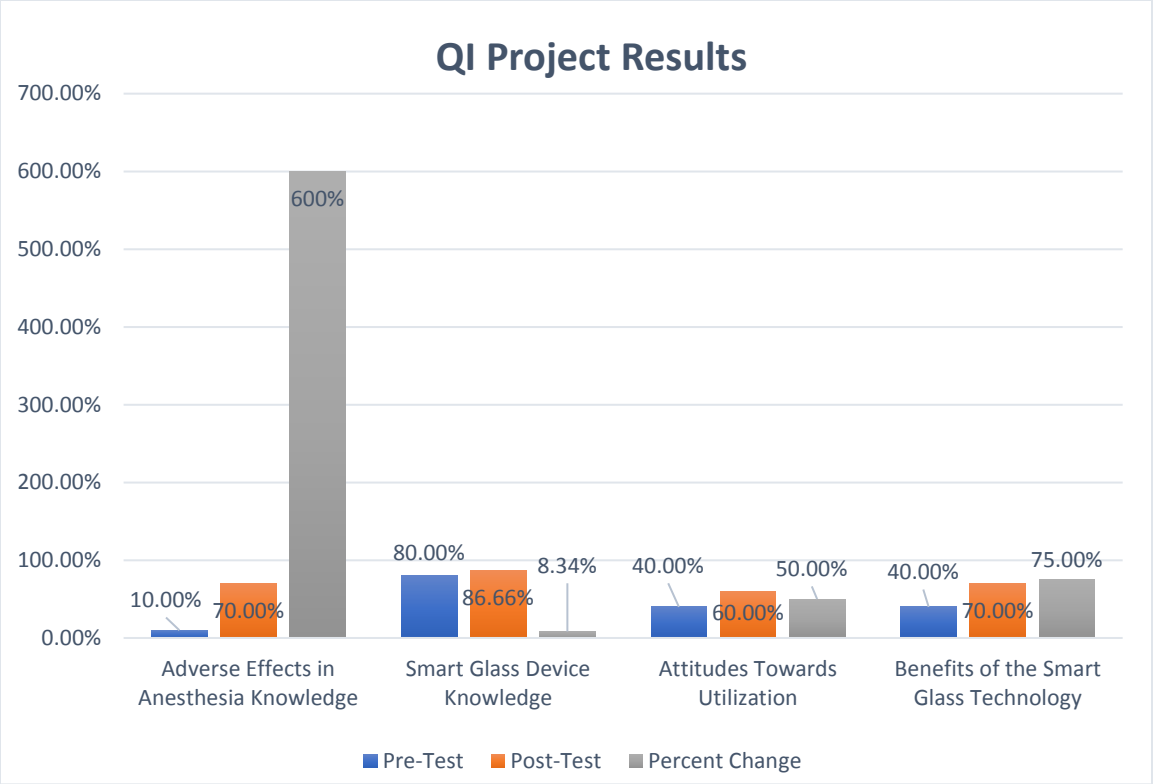
In this QI project, there were limitations noted, small sample size was a limitation despite the large number of potential participants invited to participate. Although there were sixty-five anesthesia providers from Memorial Regional Hospital invited to participate, five CRNAs completed the pre-test, and the post-test. After the educational module was launched, anesthesia providers were reminded twice via email to participate, and the window to participate was one month long. The online modality of the educational module also contributed to this QI project's limitations since the project was asynchronous and completed entirely online. While the educational module delivery method posed as a barrier to presenting the material to more

providers, this QI project would have benefited from a live presentation format in efforts to improve recruitment. Another limitation of this QI project was the inclusion of one hospital facility. Potential factors to mitigate limitations are to address issues with recruitment, allow for expansion of participation to other sites, and extend the period to participate.

Summary

The results show that there was a statistical difference between the pre-and post-tests. The average amount of correct answers in the incidence of adverse events during the administration of anesthesia knowledge was 10.00%, and an average of 70.00% correct answers were noted in the post-test. The average number of correct answers in the smart glass technology knowledge pre-test was 80.00%, and 86.66% of correct answers were reflected in the post-test. There was a significant improvement in the attitudes toward using the smart device. The average amount of anesthesia providers inclined to utilize the smart glass technology during the provision of anesthesia was 40.00% in the pre-test and 60.00% in the post-test. Overall, knowledge of the benefits of the smart glass technology to the anesthesia provider also increases from 40.00% in the pre-test to 70.00% in the post-test. The following figure demonstrates the findings.

Figure 1. ***QI Project Results***



Future Implications for Advanced Nursing Practice

Implementing the educational module can function as a segue in anesthesia practice change. By showcasing literature on the smart glass technology and its use and benefits to the anesthesia field, the information available to anesthesia providers can influence the inclination to use the device in anesthesia practice. The impact of the intervention is vital because its educational efficacy and ability to influence the attitudes of anesthesia providers regarding smart device use can affect perioperative patient outcomes. The data showed that the QI project increased anesthesia providers' knowledge and attitudes. The findings appreciated in this QI project can trigger further research considering using the smart device to secure the patient's airway, intra-operative vital sign monitoring, multi-patient monitoring and ultra-sound guided regional techniques, and arterial and central line cannulations. Current research is in its early

stages, and there is a need for further research on the benefits of smart glass during the administration of anesthesia.

Conclusions

The results of this QI project offered valuable insight into how anesthesia provider knowledge and attitudes are affected by an educational module considering the use of the smart glass technology as an adjunct in the administration of anesthesia. The findings assumed a positive relationship; anesthesia provider knowledge of smart devices and benefits to practicing, inclination to utilize the smart device increased, and overall attitudes improved. Ultimately, this QI project was able to respond to the following research question: (P) In patients receiving anesthesia (I), does the utilization of smart glasses in the perioperative period (C) compared to no smart glasses (O) improve provider knowledge and attitude, situational awareness, decrease medical and human errors, adverse events and increase the quality of care?

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Appendices

Appendix A: Summary of the Literature Table

An exploratory clinical evaluation of a head-worn display based multiple-patients monitoring application: impact on supervising anesthesiologist's situation awareness.

Theme: Improved situational awareness

Citation	Design/Method	Sample/ Setting	Major Variable Studied and Their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Schlosser et al,[1] 2019	Randomized controlled, crossover design.	Eight anesthesiologists from the University Hospital in Würzburg, Germany.	Independent variable= Head worn display Dependent Variable= Situational awareness, the percentage of patient alarms noticed by the anesthesiologist.	Wilcoxon Signed Ranks Tests to analyze the quantitative data. The qualitative data were analyzed using thematic analysis.	The quantitative data showed that the anesthesiologists noticed a significantly larger percentage of patient alarms in the HWD condition, for a median [IQR] of 66.7% [53.1%, 93.1%] compared with the control condition, 7.1% [4.7%, 8.8%], $P = 0.028$. The median [IQR] number of patient alarms occurring within the 3-h periods in the HWD condition, 42.0 [33.3, 45.3] and in the control condition, 40.5 [34.5, 60.3] showed no significant difference, $P = 0.753$. The qualitative data are not sufficient to draw conclusions about level 2 and level 3 situation awareness. However, in the interviews all anesthesiologists stated that the HWD supported them in comprehending their environment (level 2 situation awareness). Seven anesthesiologists also stated that the HWD affected their future actions (level 3 situation awareness).	The median number of patient alarms was similar when the anesthesiologists monitored with the head-worn display (42.0) and without the head-worn display (40.5). Nevertheless, the anesthesiologists noticed significantly more patient alarms with the head-worn display (66.7%) than without (7.1%), $P = 0.028$, and reported improved situational awareness with the head-worn display. The head-worn display helped the anesthesiologists to perceive and comprehend patients' status and to anticipate future developments. A negative effect of the head-worn display was its tendency to distract during demanding procedures.	In multiple-patient monitoring, situational awareness can be improved by the supervising anesthesiologists' wearing a head-worn display device.	Situation awareness was not measure quantitatively using a standard method, such as the Situation Awareness Global Assessment Technique or the Situation Present Assessment Method. The number of participants in the study was small. The anesthesiologists may have noticed more alarms in the HWD condition in order to perform "well" in the study or because the HWD was novel, and the anesthesiologists were motivated to use it. The presence of the HWD in the HWD condition might have kept the anesthesiologists aware of their participation in a study and reminded them to press the push-button when an alarm occurred.

Design and Evaluation of a Head-Worn Display Application for Multi-Patient Monitoring

Theme: Increase situational awareness for supervising anesthesiologist.

Citation	Design/Method	Sample/ Setting	Major Variable Studied and Their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Kuge et al,[13] 2021	An exploratory evaluation.	Six anesthesiologists from the University Hospital of Würzburg.	Independent variable= Head-worn display device. Dependent Variable= Situational awareness	Thematic analysis.	All participants showed clear reactions to alarm notifications (level 1 SA). Typically, an alarm resulted in a subsequent speech command to open the patient's detailed screen. In addition, videos analysis of the interviews showed that the HWD was scanned frequently. Two participants (P1 and P6) explicitly they would not have become aware of some situations without the HWD. The HWD affected the comprehension of information meaning (SA level 2). Several participants (P2, P3, P4) mentioned that the historic trend data on a room's detailed screen was well- suited to judge whether changes in vital sign parameters were sudden or whether they had happened more slowly over time. There was a high degree the participants were successful in understanding the situation in other rooms. P5 indicated that due to the HWD they "did not need to ask as many questions when on the phone".	100% participants reacted clear to the alarm notification. 50% of participants stated that the HWD affected their comprehension of information (level 2 SA).	The study demonstrated that a HWD for multi-patient monitoring can support the development of situational awareness and decision-making processes of supervisors by presenting relevant information and incorporating adequate means of human-technology interaction. Future efforts should focus on reducing mental workload when continuously monitoring with an HWD.	First, al- though the simulation was found to be representative of a busy operation suite, our results are not necessarily applicable to other situations. The HWD might have been used differently while physically assisting a junior anesthesiologist during a critical procedure or while walking in the hallway. In comparison to a regular shift, the study scenario was rather short and included several non-routine events in rapid succession. The participants would probably have needed more time to get used to the new device and to develop specific strategies to use the HWD to maximum effect and efficiency. Although qualitative evaluations like ours can provide a wide range of information, objective measurements and a higher number of participants are necessary to reduce subjective bias.

Ultrasound-Guided Central Venous Access Using Google Glass

Theme: Improved ergonomics

Citation	Design/Method	Sample/ Setting	Major Variable Studied and Their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Wu et al,[11] 2014	Randomized control trial. Pilot study.	Forty participants first- and fourth-year emergency medical residents at a Level I trauma located in a major metropolitan area.	Independent variable=Google Glass to perform an ultrasound-guided central venous access. Dependent variable= Total time required to perform the procedure, time spent looking at the patient, Time spent looking at the monitor, number of looks at the monitor, Number of needle redirections.	Statistical analysis was per-formed to assess for significance between groups using the nonparametric Mann-Whitney U-Test. A *P* value was considered significant if <0.05. All video footage was reviewed and analyzed by three independent observers.	The Google Glass group on average took longer to perform the procedure at every training level. This increased procedure time reached significance in the MS4 (197 s vs. 91 s, $p \leq 0.05$) and PGY3 (151 s vs. 52 s, $p \leq 0.05$) training levels. In the PGY3 training level, participants spent significantly more time focusing their gaze on the patient (48 s vs. 23 s, $p \leq 0.05$), as well as on Google Glass's monitor (103 s vs. 29 s, $p \leq 0.05$) compared to the non-Glass group. MS1 wearing Google Glass spent significantly more time (139 s vs. 47 s, $p \leq 0.05$) looking at the monitor compared with the non-Glass group. Both groups at all training levels had similar ($p > 0.05$) experience performing central venous lines on both live and simulated patients. Analysis of the post-exercise survey showed that most of the respondents were not familiar with the concepts of augmented reality or wearable computing before the study ,75% and 60%, respectively. 87% reported that the device was comfortable to use for the purpose of ultrasound guidance.	Subjects using Google Glass for ultrasound-guided central venous catheter cannulation took longer to complete the procedure than subjects using traditional ultra-sound guidance. A large majority of subjects found Google Glass to be a comfortable and convenient means of receiving ultrasound guidance.	Google Glass wearers, on average, took longer to gain access and had more needle redirections, but fewer head movements were noted.	Small sample size of participants recruited to participate in data collection. The wireless connection between the Google Glass unit and the ultrasound machine consistently exhibited a time delay (lag) of around 1 second. Google Glass's limited battery life complicated data collection by requiring multiple breaks between subjects to charge. Google Glass also would produce noticeable heat to the point of mild discomfort the longer the unit was streaming the ultra- sound feed.

Use of smart glasses for ultrasound-guided peripheral venous access: a randomized controlled pilot study

Theme: Improvement of provider ergonomics.

Citation	Design/Method	Sample/ Setting	Major Variable Studied and Their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Lim et al,[6] 2019	Randomized, crossover-design, simulation study.	12 emergency department residents (PGY-2-PGY5), at a university hospital in Korea.	Independent variable=Smart glasses use during ultra-sound guided peripheral venous access Dependent variable= Procedure time in seconds, number of head movements, number of skin punctures, number of needle re-direction, subjective difficulty.	Outcome variables were described using medians and interquartile ranges (IQRs). Mann-Whitney U-tests were used to compare outcomes between the two arms. IBM SPSS Statistics ver. 21 was used for statistical analysis, and *P*-values <0.05 were considered statistically significant.	No significant differences in procedural time were observed between the groups (non-glasses group: median time, 15.5 seconds; interquartile range [IQR], 10.3 to 27.3 seconds; glasses group: median time, 19.0 seconds; IQR, 14.3 to 39.3 seconds; P=0.58). The number of head movements was lower in the glasses group than in the non-glasses group (glasses group: median, 0; IQR, 0 to 0; non-glasses group: median, 4; IQR, 3 to 5; P<0.01).	No notable difference in procedure time between the glasses and non-glasses groups. The number of head movements was significantly higher in the non-glasses group than in the glasses group. No significant differences in the number of skin punctures or needle redirections were observed between the groups. Participants in the glasses group reported greater subjective difficulty than those in the non-glasses group (glasses group: median VAS, 30; IQR, 20 to 65; non- glasses group: median VAS, 15; IQR, 0 to 30; *P*=0.04).	No significant differences observed in the time required for successful ultrasound-guided peripheral venous access based on the use of smart glasses. However, fewer head movements were required when using smart glasses. Given these benefits, smart glasses may be particularly suitable for emergency situations.	Small sample size, which was not predetermined for securing statistical significance. Neither the participants nor the researcher who controlled the actual simulation were blinded, which may have resulted in performance bias. The study was conducted in a simulated setting, unable to examine the utility of smart glasses in actual practice.

Ultrasound-Guided Regional Anesthesia Using a Head-Mounted Video Display: A Randomized Clinical Study

Theme: Decrease procedure time and improve ergonomics.

Citation	Design/Method	Sample/ Setting	Major Variable Studied and Their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Przkora, et al,[7] 2021	Randomized clinical study	Twenty-four patients were randomized to receive a regional anesthetic at the University of Texas Medical Branch	Independent variable= Head-mounted video display Dependent variable= Time until satisfactory nerve block obtained, number of attempts, head rotations, and number of adjustments to ultra-sound probe.	T-test and a *P*< .05 was considered statistically significant.	Regional anesthetics performed with the HMD were delivered significantly faster than with the conventional ultrasound-guided approach (*P* < .05; mean: 59.08 vs 175.08 seconds; standard deviation [SD]: 42.46 vs 171.51). There were significantly fewer provider head movements with the HMD (*P* < .05; mean: 0.83 vs 4.75 head movements; SD: 0.83 vs 2.30; and attempts (*P* < .05; mean: 1 vs 1.42 attempts; SD: 0 vs 0.52).	Regional anesthetics performed with the HMD were significantly faster and with significantly fewer head movements. Using the HMD also drastically reduced of ultra-sound probe manipulation.	The HMD could provide advantages in regional anesthesia by decreasing the time and attempts and improving ergonomics.	Neither the observer nor providers were blinded to the way the blocks were performed. Setting up HMD goggles by connecting them with cables to the ultrasonography machine was tedious and required extra time, using wireless technology could help in limiting regional block areas in a more ergonomic way for providers.

Evaluation of the head-mounted display for ultrasound-guided peripheral nerve blocks in simulated regional anesthesia
Theme: Decrease procedure time and improve ergonomics

Citation	Design/Method	Sample/ Setting	Major Variable Studied and Their Definition	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Przkora et al,[9] 2015	Randomized control trial.	Two faculty and 18 anesthesia residents from the University of Texas Medical Branch Department of Anesthesiology	Independent variable= Head-mounted display Dependent Variable= Time taken to perform stimulated nerve block, number of provider head movements and ultra-sound probe redirections.	80% power and alpha =5 0.05, a sample of N 5= 20 would be sensitive enough to detect effect sizes (for mean differences) of at least Cohen's d= 0.66. Results were analyzed using a paired t-test and significance was accepted with $P < 0.05$.	Participants were significantly faster placing the needle to the target in the phantom when using the HMD compared to without (P50.001, mean 7.1 vs 10.9 second, SD 3.5 vs 6.7). Participants using the HMD moved the ultrasound probe significantly less compared with the procedure without HMD (P 5 0.016, mean 1.4 vs 2.3 movements, SD 0.9 vs 1.9). Additionally, the HMD decreased the number of head movements significantly during the procedure (P 5 0.0002, mean 1.2 vs 4 movements, SD 0.8 vs 2.8). The results were not influenced by the level of training.	Participants were significantly faster (7.1 vs. 10.9 seconds) performing the simulated block with the HMD than without. In addition, the HMD significantly decreased the number of operator head and ultrasound probe movements.	Based on the results, there are sufficient ergonomic and time advantages to using an HMD for ultrasound-guided needle placement that a clinical study to validate this observation and identify if an HMD is also useful in more complex clinical settings of regional anesthesia and vascular access procedures would be beneficial.	Simplicity of the "simulation" setting. The observers and participants were not blinded to the intervention.

Preliminary Study of Ergonomic Behavior During Simulated Ultrasound- Guided Regional Anesthesia Using a Head-Mounted Display

Theme: Improved ergonomics

Citation	Design/Method	Sample/ Setting	Major Variable Studied and Their Definition	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Udani et al,[10] 2012	Pilot study.	Two anesthesia providers, one expert and one novice from VA Palo Alto Health Care System	Independent variable= Head-mounted display device. Dependent variable= The number of poor ergonomic episodes, these behaviors include head turning of 45° or more, an arching torso.	An independent investigator measured the number of poor ergonomic episodes associated with behavior while performing the blocks.	Each practitioner performed 5 procedures for a total of 10 ultrasound-guided sciatic nerve blocks. All 10 procedures were adequately completed according to observation of the circumferential injectate spread in 4 of 4 quadrants around the sciatic nerve. There were no episodes of poor ergonomics noted. Specifically, neither practitioner was seen redirecting his attention away from the procedural field to directly view the ultrasound monitor while performing any of the procedures. No intraneural injections were observed.	There were no episodes of poor ergonomics noted. Neither practitioner reported difficulty with the tethered nature of the head-mounted display or its weight, and both stated that the image quality was acceptable for performing each block. The novice practitioner preferred the head-mounted display because of the ease of needle control and hand-eye coordination.	The results of this pilot study suggest potential ergonomic benefits associated with using head-mounted display technology in ultrasound-guided regional anesthesia.	Small sample size. The performance review was not blinded, and there was no comparison made between the expert and novice. The in vitro animal model under investigation may not be representative of actual clinical situations.

Feasibility of the head-mounted display for ultrasound-guided nerve blocks: a pilot simulator study

Theme: Improved ergonomics with complex techniques

Citation	Design/Method	Sample/ Setting	Major Variable Studied and Their Definition	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Kasuya et al,[8] 2017	A non-clinical crossover designed study.	Eight board-certified anesthesiologists at Tokyo Women's Medical University in Japan.	Independent variable= Head-mounted display Dependent variable= The procedure time, fractional percentage time and success rate.	The procedure time, fractional percentage time and success rate were determined from the recorded video image and comparisons were made between the control and HMD setting using the paired *t* test and chi-squared test; a P value <0.05 was considered statistically significant.	The needle insertion times were 10.4 ± 7.2 s with the control method and 6.8 ± 5.3 s with the HMD method for the standard approach ($p = 0.03$), and 18.1 ± 10.1 with the control method and 11.8 ± 9.5 s with the HMD method for the upside-down approach ($P = 0.002$). The fractional percentages of time with the needle visible on the ultrasound image were 34.1 ± 20.9 with the control method and 56.5 ± 13.6% with the HMD method for the standard approach ($p < 0.001$), and 20.1 ± 13.4 with the control method and 38.2 ± 21.2% with the HMD method for the upside-down approach ($P= 0.001$).	In the standard and upside-down approaches, times were shorter, and fractional percentages were significantly higher with the HMD method than with the control method. Although not proven statistically, the success rate of the HMD method was superior to the control method in both approaches. HMD contributed to improving needle visibility in the ultrasound image and reduced the time to reach the target.	This pilot study using a simulation model indicated that the use of an HMD shortened the procedure time and improved the needle visibility on ultrasound.	Small sample size and a lack of variation in the examinees.

Smart Glasses for Radial Arterial Catheterization in Pediatric Patients: A Randomized Clinical Trial

Theme: Improvement in successful first-time invasive line placement, ergonomics, and decreased procedure time

Citation	Design/Method	Sample/ Setting	Major Variable Studied	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Jang et al,[5] 2021	This prospective, single-blinded, randomized controlled trial.	116 pediatric patients age, less than 2 years at a teaching hospital in the Republic of Korea.	Independent variable= Smart glasses use for radial artery catheterization Dependent Variable= First-attempt success, procedure time, number of attempts.	All data expressed as means ± SD or median, interquartile range. The distribution was tested using the Shapiro–Wilk normality test. The baseline characteristics of the study population were evaluated using the independent *t* test and Mann–Whitney U test. The primary outcome was evaluated using the χ^2 test, whereas secondary outcomes were evaluated using the χ^2 test, independent *t* test, and Mann–Whitney U test. Using the proportional hazards assumption, the Kaplan–Meier analysis of the overall procedure time to successful cannulation of the chosen radial artery was performed, and the data were compared between the groups using the log-rank test. Statistical analyses were performed using IBM SPSS Statistics 22	The smart glasses group had a higher first-attempt success rate than the control group (87.9% [51/58] *vs*. 72.4% [42/58]; $P = 0.036$; odds ratio, 2.78; 95% CI, 1.04 to 7.4; absolute risk reduction, –15.5%; 95% CI, −29.8 to −12.8%). The smart glasses group had a shorter first-attempt procedure time (median, 33 s; interquartile range, 23 to 47 s; range, 10 to 141 s) than the control group (median, 43 s; interquartile range, 31 to 67 s; range, 17 to 248 s; $P = 0.007$). The overall complication rate was lower in the smart glasses group than in the control group (5.2% [3/58] *vs*. 29.3% [17/58]; $P = 0.001$; odds ratio, 0.132; 95% CI, 0.036 to 0.48; absolute risk reduction, 24.1%; 95% CI, 11.1 to 37.2%). The proportion of positive ergonomic satisfaction (4 = good or 5 = best) was higher in the smart glasses group than in the control group (65.5% [38/58] *vs*. 20.7% [12/58]; $P <0.001$; odds ratio, 7.3; 95% CI, 3.16 to 16.8; absolute risk reduction, –44.8%; 95% CI, –60.9% to –28.8%).	First-attempt success rate of radial artery cannulation was significantly higher in the smart glasses group than in the control group (87.9% [51 of 58] *vs*. 72.4% [42 of 58]; $P = 0.036$; odds ratio, 2.78; 95% CI, 1.04 to 7.4; absolute risk reduction, −15.5%; 95% CI, −29.8 to −12.8%). The overall procedure time of arterial cannulation was shorter in the smart glasses group (median, 37 s; interquartile range, 24 to 57 s; range, 10 to 547 s) than in the control group (median, 58 s; interquartile range, 39 to 251 s; range, 17 to 981 s; $P < 0.001$). The overall number of attempts was smaller in the smart glasses group (median, 1; interquartile range, 1 to 1; range, 1 to 3) than in the control group (median, 1; interquartile range, 1 to 2; range, 1 to 5; $P = 0.027$).	Smart glasses-assisted ultrasound-guided radial artery catheterization improved the first-attempt success rate and ergonomic satisfaction while reducing the first-attempt procedure time and overall complication rates in small pediatric patients.	The operators were not blinded to group allocation. Although they were allowed to use their preferred settings to maximize the success rate in the control group, the non-blindness might result in biased estimates of ergonomic satisfaction scores. The number of head or eye movements was not recorded. Because each operator has a familiar posture during radial artery cannulation, it was difficult to quantify the head or eye movement. Instead, the operators' ergonomic satisfaction score was recorded. The time to obtain an ultrasound image of the radial artery was not recorded. Because the operators in the current study were experienced in ultrasound-guided arterial cannulation of pediatric patients, obtaining the image of the radial artery took only a few seconds. Therefore, the effect of smart glasses on pediatric radial artery cannulation by physicians with less experience is unknown

Augmented Reality-Assisted Video Laryngoscopy and Simulated Neonatal Intubation: A pilot study.

Theme: Improvement of intubation.

Citation	Design/Method	Sample/ Setting	Major Variable Studied and Their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Dias et al,[3] 2021	Randomized control trial (RCT).	45 neonatal intensive care nurses at Duke University Medical Center, with minimal simulated intubation experience.	Independent Variable= Augmented reality-assisted video laryngoscopy. Dependent variable= successful placement of the endotracheal tube (ETT) in the in the airway in <30 seconds.	Statistical analyses were performed by using Fisher's exact test. The Kruskal-Wallis test was used to compare among all groups the time to intubate. Comparisons was assessed between the DL and IVL groups, between the DL and ARVL groups, and between the IVL and ARVL groups by using the Wilcoxon rank sum test. *P* values of <.05 were considered statistically significant.	The overall success rate of intubation attempts done with DL was 32% (24/75) compared to 72% (54/75) using IVL and 71% (53/75) using ARVL ($P < .001$). Esophageal intubations occurred in 27% (20/75) of attempts in the DL group, whereas there were no esophageal intubations in the IVL or ARVL groups ($P < .001$). The DL group had 16 of 75 (21%) failures to intubate within 60 seconds, whereas the IVL group had 5 of 75 (7%) and the ARVL group had 8 of 75 (11%) failures to intubate within 60 seconds ($P = .03$). The median (interquartile range [IQR]) number of successful intubations per participant in the DL group was 1 (0–3) compared to 4 (3–4) for both the IVL and ARVL groups ($P = .002$). Notably, 47% (7/15) of providers in the DL group had no successful intubations, whereas all (15/15) providers in the IVL group and 93% (14/15) of providers in the ARVL group had at least 1 successful intubation ($P = .003$)	The DL group successfully intubated on 32% of attempts compared to 72% in the IVL group and 71% in the ARVL group ($P < .001$). The DL group intubated the esophagus on 27% of attempts, whereas there were no esophageal intubations in either the IVL or ARVL groups ($P< .001$). The median (interquartile range) time to intubate in the DL group was 35.6 (22.9–58.0) seconds, compared to 21.6 (13.9–31.9) seconds in the IVL group and 20.7 (13.2–36.5) seconds in the ARVL group ($P < .001$).	Simulated intubation success of neonatal intensive care nurses was significantly improved by using either IVL or ARVL compared to DL.	The small sample sizes increased the impact of outliers on the data. Specifically, 1 participant in the ARVL group had much lower success rates than the other 14 participants. We chose not to exclude outliers from the analyses because this was not prespecified in our protocol. However, it is worth noting that the results may have been skewed, leading to the possibility that ARVL may have been more efficacious in some parameters than IVL. Additional limitation was on the reliance of self-reporting by the DL group regarding their visual identification of the airway. A weakness was the use of an intubation manikin, the limitations of which are underscored by the fact that all 3 groups showed significant improvements in intubation skills throughout their subsequent attempts. The results may not be generalizable, because the study participants were nurses, a population unlikely to intubate live patients.

The use of Google glass for airway assessment and management

Theme: Improved airway management and assessment

Citation	Design/Method	Sample/ Setting	Major Variable Studied	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Spencer et al,[16] 2014	Case studies	Case 1 A previously well 20-year-old male from a Caribbean country suffered a 30% total body surface flame burn and facial fractures during a motorcycle accident and gasoline explosion. Case 2 A 2-year-old girl was scheduled for excision and grafting of burns. with Google Glass.	Independent variable= Google glass Dependent variable=Improved airway assessment and management	None stated	Good visualization of the airway assessment and tracheal intubation was obtained with Google Glass, with no disruption to workflow and no additional lighting. A video of the intubation process, generated from the visual perspective of the operator, has potential as a useful tool for teaching, self-assessment, and comparison of techniques between different clinicians. It may also be used to record the management of difficult airways and failed intubations, for clinical quality control purposes.	Case 1 Good visualization of the airway assessment and tracheal intubation was obtained with Google Glass, with no disruption to workflow and no additional lighting. Case 2 The use of the google glass allowed for videoing of the intubation process, this video serves as a powerful potential tool for teaching, self-assessment, and comparison of techniques between different clinicians. It may also be used to record the management of difficult airways and failed intubations, for clinical quality control purposes.	Google glass can be used to document airway assessment and management under standard lighting conditions, with minimal disruption to workflow. This novel way to capture more comprehensive data has potential implications for anesthetic airway management.	None stated

The effectiveness of Google GLASS as vital signs monitors in surgery: A simulation study

Theme: Improved of vital signs monitoring

Citation	Design/Method	Sample/ Setting	Major Variable Studied	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Iqbal et al,[12] 2016	Prospective, observational, and comparative study	37 medical students from institutions in the United Kingdom.	Independent variable= Google glass during surgery Dependent variable= Time taken to respond to change in vital signs, effect of Google GLASS on technical performance, effect of Google GLASS on non-technical performance, assessed by measuring average heart rate in both sessions, and the acceptability and feasibility of using the Google GLASS during surgical procedures.	Statistical analysis was performed using *GraphPad version 6.0*. Comparison between novices, intermediate and expert candidates in standard monitor and Google GLASS sessions along with survey response were analyzed using the non-parametric Mann-Whitney *U* test. A p-value of <0.05 was considered statistically significant in both tests.	A significant proportion (84%) of participants responded to abnormal vital signs quicker when performing the simulated operation for the second time using the Google GLASS, with 100% of experts responding faster on the second operation. Overall global simulation score for novice (mean: 177), intermediate (mean: 314) and expert (mean: 420) participants were assessed demonstrating a statistically significant difference between novices and intermediates (P= 0.0038) and novices and experts ($p < 0.0001$). Global score comparison between intermediates and experts was not statistically significant (P= 0.13). Participants' heart rates (HR) were constant whilst using a standard monitor (Mean: 84 bpm [beats per minute]) and the Google GLASS (Mean: 80 bpm). Majority of novices (79%), intermediates (75%) and experts (80%) agreed that the Google GLASS increased their awareness of vital signs whilst 71% of novices, 75% of intermediates and 100% of experts agreed that they would like to use the GLASS in another surgical procedure in the future.	The majority (84%) of participants responded quicker to abnormal signs with the Google GLASS compared to a standard monitor (P = 0.0267). The average simulation score during a standard-monitor and GLASS-session scored to be statistically insignificant (P = 0.253). All parameters of simulation were also similar in both sessions including average sweep speed (P = 0.594), average blood loss (P= 0.761) and average grams vaporized (P = 0.102).	This study has demonstrated that head-mounted displays such as the Google GLASS are potentially useful in surgery to aid patient care without hampering the surgeon's view.	Participants who already wore glasses reported that it was uncomfortable to wear the GLASS over their regular spectacles. Google GLASS used required re-charging every 2–3 h, making it impractical for use in its current form. The current design of the glass only have optical view in front of the right eye; users who are left handed reported significant discomfort with this design specification.

Monitoring with Head-Mounted Displays in General Anesthesia: A Clinical Evaluation in the Operating Room

Theme: Decrease distraction

Citation	Design/Method	Sample/ Setting	Major Variable Studied	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Liu et al,[14] 2010	Randomized control trial, a 2 (display) × 3 (trial) repeated-measures design	6 attending anesthesiologists from the Royal Adelaide Hospital and the University of Queensland.	Independent variable= Head-mounted displays Dependent variable= The dependent variables were the percentage, frequency, and duration of participants' head turns toward the anesthesia workstation and toward the patient/surgical field.	Differences in the percentage, frequency, and duration metrics from the head-turning data were independently tested for significance with Statistica 8 using a repeated-measures analysis of variance for each measure with $\alpha = 0.05$, 2-tailed.	For the percentage of time the anesthesiologist was looking toward an object, there were main effects of phase ($P < 0.001$) and gaze location ($P < 0.001$) but no effect of display or trial (Fig. 4). Moreover, there was a significant interaction between phase and gaze location ($P < 0.001$) and between display and gaze location ($P < 0.001$). For the frequency of head turns toward an object, there were main effects of phase ($P = 0.018$) and gaze location ($P = 0.011$), a significant interaction between phase and gaze location ($P = 0.002$), but no effects of display or trial. Participants looked more frequently toward the patient/surgical field (5.0 head turns/min) than toward the anesthesia workstation (3.9 head turns/min).	Video data were collected from 36 cases that ranged from 17 to 75 minutes in duration (median 31 minutes). When participants were using the HMD, compared with standard monitoring, they spent less time looking toward the anesthesia workstation (21.0% vs 25.3%, $P = 0.003$) and more time looking toward the patient and surgical field (55.9% vs 51.5%, $P = 0.014$). The HMD had no effect on either the frequency of looks or the average duration of looks toward the patient and surgical field or toward the anesthesia workstation.	An HMD of patient vital signs reduces anesthesiologists' surveillance of the anesthesia workstation and allows them to spend more time monitoring their patient and surgical field during normal anesthesia. More research is needed to determine whether the behavioral changes can lead to improved anesthesiologist performance in the operating room.	The time participants were using the HMD spent looking toward the patient and surgical field with the HMD was relatively small (4.4% difference), and their time looking at the anesthesia workstation was still substantial (21.0% of the case). These statistics may underrepresent the difference in monitoring patterns as a result of HMD use. Even with an HMD, the anesthesiologist would still need to look at the anesthesia workstation to perform tasks (e.g., adjusting gas flows) or monitor information not available on the HMD (e.g., ventilator settings and documentation). The weight and bulk of the head-mount and backpack equipment was a major concern for participants. Participants only experienced the HMD for only 2 hours during the study. They may not have had sufficient time to break their existing monitoring habits.

Novel Use of Google Glass for Procedural Wireless Vital Sign Monitoring

Theme: Improved vital sign monitoring

Citation	Design/Method	Sample/ Setting	Major Variable Studied and Their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Liebert et al,[15] 2016	Randomized controlled trial with crossover design	14 postgraduate year (PGY)-1 to PGY-5 surgical residents in an Accreditation Council for Graduate Medical Education (ACGME)-training program.	Independent variable=Google glass Dependent Variable= time to recognition of decreasing vital signs, number of glances at traditional monitor, and time spent looking away from the procedural field to view the traditional vital sign monitor.	Mean and standard deviation were calculated for all continuous variables. Effect size was calculated as Cohen's d. Student's t test was used to determine whether there was a statistically significant difference in continuous variables between the control and experimental groups. Chi-square test was performed to assess for statistical significance of proportions. A P value ≤.05 was considered statistically significant.	The experimental group spent 90% less time looking away from the procedural field to view traditional monitors during bronchoscopy ($P = .003$) and recognized critical desaturation 8.8 seconds earlier; the experimental group spent 71% ($P = .01$) less time looking away from the procedural field during thoracostomy, and recognized hypotension 10.5 seconds earlier. Trends toward earlier recognition of deterioration did not reach statistical significance. Most participants agreed that Google Glass increases situational awareness (64%), is helpful in monitoring vitals (86%), is easy to use (93%), and has potential to improve patient safety (85%)	Scenario 1: Chest Tube Placement. While performing bedside thoracostomy tube placement, the experimental group recognized severe hypotension 10.1 seconds earlier than the control group (31.8 and 41.9 seconds, $P > .05$). Scenario 2: Bronchoscopy. Wireless streaming of vital signs to Google Glass resulted in a nonsignificant trend toward earlier recognition of critical desaturation and progression to ventricular tachycardia, with the experimental group recognizing critical desaturation 8.8 seconds earlier than the control group (64.6 vs 73.4 seconds, $P > .05$)	Use of Google Glass significantly decreased time looking away from procedural fields and resulted in a nonsignificant trend toward earlier recognition of vital sign deterioration. Vital sign streaming with Google Glass or similar platforms is feasible and may enhance procedural situational awareness.	Limited statistical power due to the small sample size, which limits the interpretation of the statistical analysis for time to recognition of vital sign deterioration. The study was performed in a simulated setting, and future studies would be needed to replicate these findings in an actual clinical environment. Google Glass requires personalized fitting to optimal viewing. This was not possible in our study for every resident, especially for those who required corrective lenses. In addition, there was limited time given for participants to become accustomed to Google Glass prior to entering the scenarios.

Patient monitoring with Google Glass: a pilot study of a novel monitoring technology

Theme: Anesthesia provider's attitudes.

Citation	Design/Method	Sample/ Setting	Major Variable Studied	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Drake-Brockman et al,[17] 2016	Pilot study	40 anesthetists at the Princess Margaret Hospital for Children, Perth, Australia.	Independent Variable= Google glass Dependent variables= willingness to use the device again, recommend it to colleagues, the contribution to patient management, how comfortable it was to wear, how easily information was able to be read, and if the anesthetist would be prepared to wear the device when in view of patients.	A questionnaire, consisting of Likert scale. Recorded sessions were analyzed.	No statistically significant difference was found between consultant and trainee anesthetists regarding the questions 'I would use the device again' ($P = 1$), or 'I would recommend the device to a colleague' ($P = 1$). Consultants were more optimistic when asked if 'The device improved patient management' than fellows or registrars ($P = 0.43$). The majority (90.0%) of anesthetists agreed that 'The device was comfortable to wear'. No significant difference was found between trainee (registrar and fellow) anesthetists in terms of device comfort ($P = 0.83$). Consultants had the least difficulty reading the information on the device ($P = 0.64$), however were also least likely to agree that they 'would wear the device in view of patients' ($P = 0.10$).	The study found that 90% of anesthetists trialing the device agreed that it was comfortable to wear, 86% agreed the device was easy to read, and 82.5% agreed the device was not distracting. In 75% of cases, anesthetists reported unprompted that they were comfortable using the device in theater. Anesthetists reported that they would use the device again in 76% of cases and indicated that they would recommend the device to a colleague in 58% of cases.	Given the pilot nature of this study, we consider these results highly favorable. Anesthetists readily accepted Google Glass in the anesthetic environment, with further enhancements to device software, rather than hard-ware, now being the barrier to adoption. There are several applications for HMDs in pediatric anesthesia.	Google have ceased production of the version of Glass used in this study.

Appendix B: QI Project IRB Exemption

MEMORANDUM

To: Dr. Ann B. Miller

CC: Mikke-Ann Tracey

From: Carrie Bassols, BA, IRB Coordinator

Date: March 1, 2023

Proposal Title: "An Educational Module Utilizing Smart Glass Technology as an Adjunct During Anesthesia and Procedural Tasks to Decrease Medical and Human Errors in the Perioperative Period"

The Florida International University Office of Research Integrity has reviewed your research study for the use of human subjects and deemed it Exempt via the **Exempt Review** process.

IRB Protocol Exemption #: IRB-23-0072 **IRB Exemption Date:** 03/01/23 **TOPAZ Reference #:** 112829

As a requirement of IRB Exemption you are required to:

1. 1) Submit an IRB Exempt Amendment Form for all proposed additions or changes in the procedures involving human subjects. All additions and changes must be reviewed and approved prior to implementation.
2. 2) Promptly submit an IRB Exempt Event Report Form for every serious or unusual or unanticipated adverse event, problems with the rights or welfare of the human subjects, and/or deviations from the approved protocol.

1) Submit an IRB Exempt Project Completion Report Form when the study is finished or discontinued.

Special Conditions: N/A
For further information, you may visit the IRB website at http://research.fiu.edu/irb.

Appendix C: QI Project Consent

FIU | FLORIDA INTERNATIONAL UNIVERSITY

CONSENT TO PARTICIPATE IN A QUALITY IMPROVEMENT PROJECT

The Utilization of the Smart Glass Technology as an Adjunct During Anesthesia and Procedural Tasks in the Perioperative Period

SUMMARY INFORMATION
Things you should know about this study:

- **Purpose:** Educational module to increase providers awareness of the use of smart glass technology as an adjunct during the provision of anesthesia and while performing procedural task in the perioperative period.
- **Procedures**: If the participant chooses to participate, they will be asked to complete a pretest, watch a voice PowerPoint, and then a post test
- **Duration:** This will take about a total of 20 minutes total.
- **Risks**: There will be minimal risks involved with this project, as would be expected in any type of educational intervention, which may include mild emotional stress or mild physical discomfort from sitting on a chair for an extended period.
- **Benefits:** The main benefit to you from this research is increase the participants knowledge on smart glass technology as in adjunct during the provision of anesthesia and while performing procedural tasks.
- **Alternatives:** There are no known alternatives available to the participant other than not taking part in this quality improvement project.
- **Participation:** Taking part in this quality improvement project is voluntary.

Please carefully read the entire document before agreeing to participate.

NUMBER OF STUDY PARTICIPANTS:

If the participant decides to be in this study, they will be one of 20 people in this research study.

PURPOSE OF THE PROJECT

The participant is being asked to be in a quality improvement project. The goal of this project is to increase providers' knowledge on the benefits and use of the smart glass technology as an adjunct during anesthesia and while performing procedural tasks in the perioperative period to decrease medical and human errors. If you decide to participate, you will be 1 of approximately 20 participants.

DURATION OF THE PROJECT

The participation will require about 20 minutes.

PROCEDURES

If the participant agrees to be in the project, PI will ask you to do the following things:
1. Complete an online 10 question pre-test survey via Qualtrics, an Online survey product for which the URL link is provided
2. Review the educational PowerPoint Module lasting 15 minutes via Qualtrics, an Online survey product for which the URL link is provided.
3. Complete the online 10 question post-test survey via Qualtrics, an Online survey product for which the URL link is provided.

RISKS AND/OR DISCOMFORTS

The main risk or discomfort from this research is minimal. There will be minimal risks involved with this project, as would be expected in any type of educational intervention, which may include mild emotional stress or mild physical discomfort from sitting on a chair for an extended period.

BENEFITS

The following benefits may be associated with participation in this project: An increased participants knowledge on the benefits of smart glass technology in the perioperative period, and as a result, a decrease in medical and human errors. The overall objective of the program is to increase the providers' knowledge based on the current literature.

ALTERNATIVES

There are no known alternatives available to the participant other than not taking part in this project. However, if the participant would like to receive the educational material, it will be provided to them at no cost.

CONFIDENTIALITY

The records of this project will be kept private and will be protected to the fullest extent provided by law. If, in any sort of report, PI might publish, it will not include any information that will make it possible to identify the participant. Records will be stored securely, and only the project team will have access to the records.

PARTICIPATION

Taking part in this quality improvement project is voluntary.

COMPENSATION & COSTS

There is no cost or payment to the participant for receiving the health education and/or for participating in this project.

RIGHT TO DECLINE OR WITHDRAW

The participation in this project is voluntary. The participant is free to participate in the project or withdraw the consent at any time during the project. The participant's withdrawal or lack of participation will not affect any benefits to which you are otherwise entitled. The investigator reserves the right to remove the participant without their consent at such time that they feel it is in their best interest.

RESEARCHER CONTACT INFORMATION

If you have any questions about the purpose, procedures, or any other issues relating to this research project, you may contact Mikke-Ann Tracey at 347-542-1447 or mtrac017@fiu.edu or Ann B. Miller at 305-348-4871 or anmille@fiu.edu.

IRB CONTACT INFORMATION

If the participant would like to talk with someone about their rights pertaining to being a subject in this project or about ethical issues with this project, the participant may contact the FIU Office of Research Integrity by phone at 305-348-2494 or by email at ori@fiu.edu.

PARTICIPANT AGREEMENT

I have read the information in this consent form and agree to participate in this study. I have had a chance to ask any questions I have about this study, and they have been answered for me. By clicking on the "consent to participate" button below I am providing my informed consent.

Appendix D: QI Project Letter of Support

Envision
PHYSICIAN SERVICES

February 7, 2023

Ann B. Miller, DNP, CRNA, APRN
Assistant Chair & Clinical Assistant Professor
Department of Nurse Anesthesiology
Florida International University

Dr. Ann B. Miller,

Thank you for inviting Envision Physician Services to participate in the Doctor of Nursing Practice (DNP) project conducted by Mikke-Ann Tracey entitled "An Educational Module Utilizing Smart Glass Technology as an Adjunct During Anesthesia and Procedural Tasks to Decrease Medical and Human Errors in the Perioperative Period" in the Nicole Wertheim College of Nursing and Health Sciences, Department of Nurse Anesthesiology at Florida International University. I have granted the student permission to conduct the project using our providers.

Evidence-based practice's primary aim is to yield the best outcomes for patients by selecting interventions supported by the evidence. This proposed quality improvement project seeks to utilize the latest literature to increase providers awareness regarding smart glass technology as an adjunct during anesthesia and while performing procedural tasks in the perioperative period.

We understand that participation in the study is voluntary and carries no overt risk. All Anesthesiology providers are free to participate or withdraw from the study at any time. The educational intervention will be conveyed by a 15-minute virtual PowerPoint presentation, with a pretest and posttest questionnaire delivered by a URL link electronically via Qualtrics, an online survey product. Responses to pretest and posttest surveys are not linked to any participant. The collected information is reported as an aggregate, and there is no monetary compensation for participation. All collected material will be kept confidential, stored in a password encrypted digital cloud, and only be accessible to the investigators of this study: Mikke-Ann Tracey and Ann B. Miller.

Once the Institutional Review Board's approval is achieved, this scholarly project's execution will occur over two weeks. Mikke-Ann Tracey will behave professionally, follow standards of care, and not impede hospital performance. We support the participation of our Anesthesiology providers in this project and look forward to working with you.

Suzanne Hale, MSN, CRNA, ARNP
Advanced Practice Provider Director, Broward and Dade
Chief, Memorial Regional Hospital
Envision Physician Services
954-265-2044

Appendix E: QI Project Pre-test and Post-test Survey

Pretest and Posttest Questionnaire:

An Educational Module on the Utilization of the Smart Glass Technology as an Adjunct During Anesthesia and Procedural Tasks to in the Perioperative Period

INTRODUCTION

The primary aim of this QI project is to increase providers awareness of the benefits of smart glass technology use during the administration of anesthesia and the performance of procedural tasks in the perioperative period.

Please answer the question below to the best of your ability. The questions are either in multiple choice, yes/no or true/false format and are meant to measure knowledge on the use of the smart glass in the perioperative procedure.

PERSONAL INFORMATION

1. **Gender:** Male Female Other_____
2. **Age:** 25-34 35-44 45-54 55-64 65 and older
3. **Ethnicity:** Hispanic Caucasian African American Asian Other_____
4. **Position/Title:** CRNA Anesthesiologist Resident Anesthesiologist Assistant
5. **Level of Education:** Certificate Bachelors Masters DNP PhD
6. How many years have you been a perioperative provider?

   Over 10 5-10 years 2-5 years 1-2 yea

QUESTIONNAIRE

1. **Has your view of the traditional patient's monitor ever been obscured during the administration of anesthesia because of the surgical position or configuration of the room:** Yes or No
2. **Up to what percentage of alarms in the critical care environment have been reported as false positives, potentially leading clinicians to become dangerously desensitized?**
    a. 20%
    b. 50%
    c. 70%
    d. 90%
3. **Approximations of preventable anesthesia-related adverse events range between?**
    a. 20%- 30%
    b. 40%-50%
    c. 50%- 60%
    d. 70%-80%
4. **Define the smart glass technology?**
    a. A device that affords the user easy access to patient information, mobility, and hands-free interaction.
    b. A device that is worn like a regular pair of eyeglasses mounted on the head, but unlike regular glasses, the SG displays information in the user's field of view through a prism in real-time.

c. The use of SG by the anesthesia provider during procedures decreasing head and eye shifting from the patient to the monitors, thus improving the anesthesia provider ergonomics.

d. All the above

5. **Prior to participating in this quality improvement project, have you ever heard about the smart glass technology? Yes or No**

6. **Smart glass technology can be used for:**

    a. Intraoperative vital sign monitoring

    b. Multi-patient monitoring

    c. Ultrasound guided: Regional anesthesia, arterial cannulation, or central line placement

    d. All the above

7. **In what way would the Smart Glass technology be MOST beneficial to you:**

    a. Intraoperative vital sign monitoring

    b. Multi-patient monitoring

    c. Ultrasound guided: Regional anesthesia, arterial cannulation, or central line placement

    d. The technology would not be beneficial to me

8. **The smart glass can be used as a tool to aid intubation.** True or False

9. **The benefits of smart technology for the anesthesia provider are:**

    a. Improves situational awareness

    b. Improves ergonomics

    c. Improves vital sign monitoring

d. All the above

10. If the smart glass technology was available for use at your hospital today, how likely are you to use the new technology?

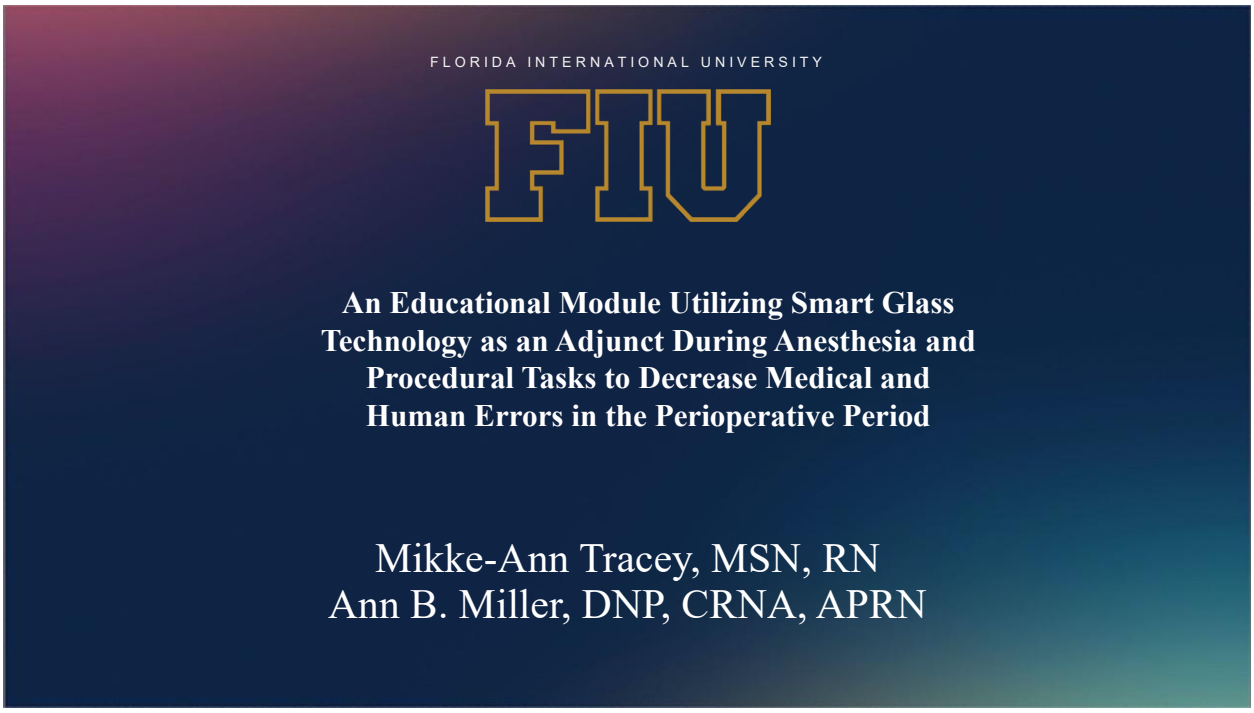
a. Most likely

b. Somewhat likely

c. Somewhat unlikely

d. Most unlikely

Appendix F: QI Project Education Module



LEARNING OBJECTIVES

From this quality improvement project, the participant will:

Describe	Describe the the smart glass technology.
Discuss	Discuss the different perioperative use of the smart glass technology.
Understand	Understand the benefits of the smart glass technology as as adjunct in the provision of anesthesia.
Formulate	Formulate ways in which the smart glass technology can improve patient safety by decreasing medical and human errors.

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BACKGROUND OF THE PROBLEM

FIU

- Human factor problems associated with patient monitors have been extensively documented in the literature
- Monitors are often awkwardly positioned outside the provider's view in the operating room
- The chief concern is that the anesthesia provider may miss important events on the monitor when their attention is overloaded during busy periods.
- Automatic acoustic alerts are quite problematic despite their simplistic nature. Up to 90% of alarms in the critical care environment have been reported as false positives – potentially leading clinicians to become dangerously desensitized.
- Auditory alarms have been accused of being offensively loud and challenging to discern.

BACKGROUND OF THE PROBLEM

FIU

- Patients requiring anesthesia today often present with complex medical history necessitating extensive VS monitoring.
- Peripheral arterial catheterization is still difficult in small pediatric patients because of their small vessel size, currently the first attempt success rate of radial arterial catheterization by well skilled personnel is 48 to 83% with US guidance.
- One of the biggest obstacle for the anesthesia provider is the constant shifting of attention from the patient to the VS monitors/ US screen while performing a task or procedure.
- For the novice provider achieving competency in intubation is increasingly difficult, with recent studies reporting first time success as low as 20 to 24%
- The preceptor is unable to see what the novice provider sees complicating the learning process.
- Information about the airway assessment and tracheal intubation is currently communicated verbally or in writing.

Scope of the Problem

Patients still suffer difficulties despite drastic improvement in anesthesia

44% of adverse events that resulted in patient harm were preventable.

Preventable anesthesia-related adverse events range between 50% and 60%.

98.4% of pediatric, obstetric and cardiothoracic anesthesiologists reported work related musculoskeletal pain.

The goal of this quality improvement project is to improve anesthesia provider vigilance, decrease anesthesia-related complications, and ensure that each patient has a safer surgical anesthetic experience.

FIU

Smart Glass Technology

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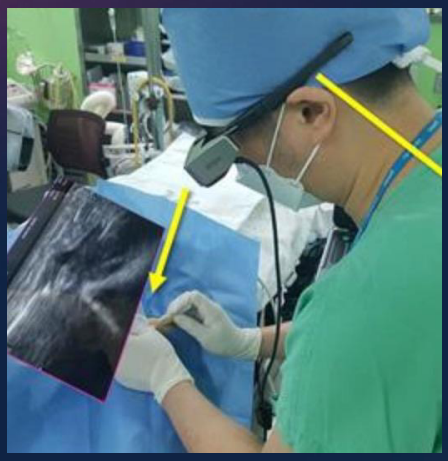
Smart glasses (SG) have been suggested in the complex anesthesia environment because the device affords the user easy access to patient information, mobility and hands-free interaction.

SGs are a wearable technology that gives users sustained, hands-free access to information and can receive and transmit data wirelessly.[3]

The smart device is worn like a regular pair of eyeglasses mounted on the head, but unlike regular glasses, the SG displays information in the user's field of view through a prism in real-time.[3,6]

The use of SG by the anesthesia provider during procedures decreasing head and eye shifting from the patient to the monitors, thus improving the anesthesia provider ergonomics.

Smart Glass Technology Use



- The SG technology allows anesthesia providers to continuously monitor patients VS intraoperatively, while the monitors view is obscure, the provider is drawing up medication or providing patient care outside the monitor's view.
- The SG technology facilitates multiple patient monitoring, improving supervising anesthesiologist's situational awareness of their patients in a hands-free, mobile manner, even in sterile situations.
- The use of the smart device can improve US guided central venous access. The ultrasound machine is stationary therefore the user must constantly shift the visual focus between the procedure site and the ultrasound screen. The SG technology places the US screen within the user's field of vision, therefore less shifting and more successful cannulation.

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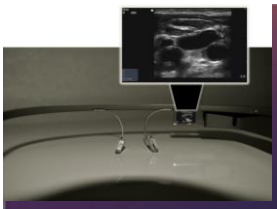

Smart Glass Technology Use

- SG is also efficacious in in obtaining peripheral venous access among pediatric patients via ultrasound technology. Smart glasses can provide ultra-sound users with instantaneous images.
- Smart glasses can also improve success for radial arterial catheterization among pediatric patients.
- Decrease procedure time and improve ergonomics in regional anesthesia.
- The SG technology aids intubation especially for novice providers as it amplifies the patient's airway and projects the image directly into the intubator's field of vision.[10] Real-time feedback to the student can be provided by the instructor who can simultaneously view the patient's airway through video streaming.
- SG can also be used as a tool for surgeons to monitor patients VS intraoperatively.

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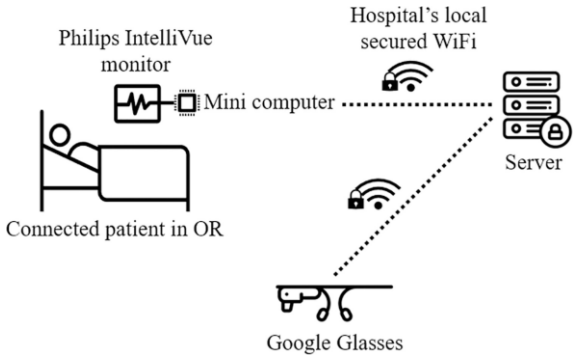
OVERVIEW OF TECHNICAL SET-UP



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Clinical Question

P	In patients receiving anesthesia
I	Does the utilization of smart glasses in the perioperative period
C	Compared to no smart glasses
O	Improve situational awareness, decrease medical, human errors, adverse events, increase quality of care, provider knowledge, and attitude? **?**

Proposed Quality Improvement via Educational Intervention

This Quality Improvement Project aims to improve anesthesia provider vigilance, decrease anesthesia-related complications, and ensure that each patient has a safer surgical anesthetic experience by:

- Bridging the knowledge to practice gap
- Educating anesthesia providers of the various benefits and use of the SG tool in anesthesia
- Serving as a catalyst to initiate the use of the Smart Glass technology in anesthetic management

Quality Improvement Methods

Location: The QI project occurred at a 797-bed public hospital in Hollywood, Florida.

Participants: A sample size of 5 (n = 5) CRNAs participants who practice under the umbrella of Envision Physician Services.

Consent: Participants provided voluntary consent through a Qualtrics questionnaire via email and were redirected to a pre-assessment survey, a video education and demonstration module, and a post-intervention survey.

The principal objective: To provide an educational module utilizing smart glass technology as an adjunct during anesthesia and procedural tasks to decrease medical and human errors in the perioperative period.

Quality Improvement Methods

Three phases: pre-test, educational module, and post-evaluation, all completed using a computer, tablet, or smartphone.

Research Approval: The project received approval from The Institutional Review Board (IRB) of Florida International University (FIU) before implementation.

Confidentiality: Strict confidentiality measures were employed throughout the project, and researchers could not access patient identifiers.

Data Collection: Involved a demographics survey, a pre-test and post-test survey conducted via anonymous Qualtrics surveys, investigating knowledge of the smart glass technology, various application in the provision of anesthesia and performing procedural tasks and willingness to implement the technology into practice.

Data Analysis: The lead investigator and DNP project supervisor managed data collection. Statistical analysis was employed to compare pre-test and post-test answers, determining changes in knowledge and attitudes among anesthesia providers.

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Pre-Test Results

Pre-Test Adverse Events During Anesthesia Knowledge

- 100.00% admitted that their view of the traditional patient monitor have been obscured during the administration of anesthesia.
- 80.00% were unaware of the percentage of alarms in the critical care environment that have been reported as false positives.
- None (0.00%) knew the incidence of anesthesia-related adverse events during the administration of anesthesia.

Pre-Test Smart Glass Technology Knowledge

- 20.00% was aware of the existence of the technology prior to participating in the study
- 80.00% had no prior knowledge of the technology .
- 40.00% presumed that the smart technology would only aid intraoperative vital sign monitoring
- 60.00% correctly predicted that the technology could also be utilized not only in intra-operative vital sign monitoring but also in multi-patient monitoring and ultra-sound guided procedures regional techniques, arterial cannulations, and central line placements
- 80.00% guessed the SG could aid intubation

Pre-Test Utilization and Attitudes of the Smart Glass Device

- 60% revealed that the benefits of the smart technology to the anesthesia provider included improved situational awareness, ergonomics, and vital signs monitoring.
- 20.00% believed the device benefits were limited only to vital signs monitoring,
- 20.00% stated the device might prove beneficial only in improving the provider's ergonomics.
- 40.00% were extremely likely, another two participants somewhat likely (40.00%), and one participant (20.00%) extremely unlikely to use the smart glass technology.
- When asked in what way would the smart glass technology be most beneficial to them, 80% stated that the smart glass technology would be most beneficial for intraoperative vital sign monitoring.
- 20.00% stated that they would use the device not only for intraoperative vital signs monitoring but also during ultra-sound guided regional anesthesia and placement of central and arterial lines .

Post-Test Results

Post-Test Adverse Events During Anesthesia Knowledge

- 100.00% admitted that their view of the traditional patient monitor had been obscured during the administration of anesthesia.
- After the educational module 60.00% were aware that the incidence of false positives was as high as 90%.
- When asked about the approximations of preventable anesthesia-related adverse events, the correct answer of 50-60% was selected by four participants 80%
- There was an increase in the knowledge of adverse anesthesia-related events. Adverse anesthesia-related events knowledge improvement was noted for all questions.

Post-Test Smart Glass Technology Knowledge

- 100.00%were able to correctly determine the correct definition of the smart glass device.
- 80% knew that in addition to intraoperative vital signs monitoring, the smart glass could also be used for multi-patient monitoring, ultra-sound guided regional procedures, and ultra-sound guided central line and arterial line placements.
- 100.0% knew the smart technology could be used as a tool to aid intubations
- When asked in the post-test the benefits of the smart technology to the anesthesia provider, four participants (80%) were able to correctly identify the correct answers compared to only 60% of participants in the pre-test.
- A knowledge improvement was noted in most questions regarding knowledge and use of the smart technology during the provision of anesthesia.

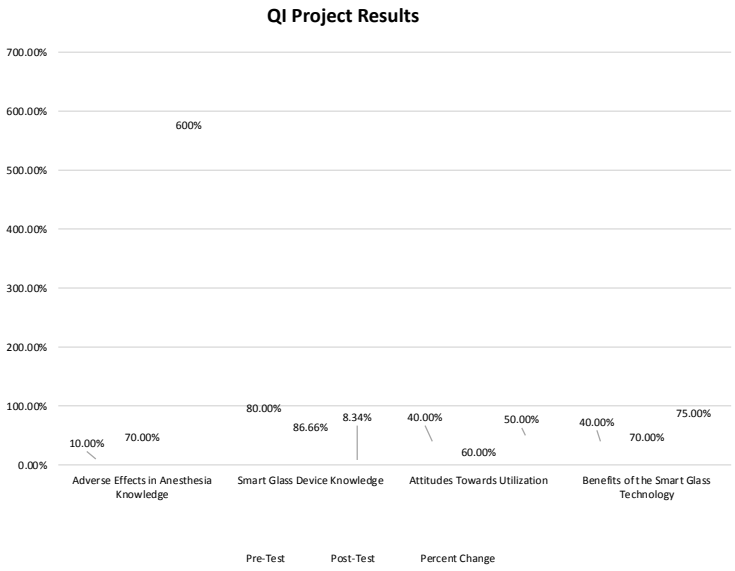
Post-Test Utilization and Attitudes of Smart Glass Device

- Attitudes towards the benefit of the smart glass to the anesthesia provider improved after the educational intervention.
- 80% participants stated that the smart glass can improve situational awareness, ergonomics, and intraoperative vital signs monitoring. After the educational module, the presumed personal benefits of the device to the participant also increased to 60%
- 60% of participants stated that they were extremely likely to use the new technology if it were available for use at their place of employment.
- No negative or very negative attitudes were expressed regarding the use of the new technology in clinical practice after the educational module.

Discussion

The results show that there was a statistical difference between the pre-and post-tests.

- The average amount of correct answers in the incidence of adverse events during the administration of anesthesia knowledge was 10.00%, and an average of 70.00% correct answers were noted in the post-test.
- The average number of correct answers in the smart glass technology knowledge pre-test was 80.00%, and 86.66% of correct answers were reflected in the post-test.
- \There was a significant improvement in the attitudes toward using the smart device. The average amount of anesthesia providers inclined to utilize the smart glass technology during the provision of anesthesia was 40.00% in the pre-test and 60.00% in the post-test.
- Overall, knowledge of the benefits of the smart glass technology to the anesthesia provider also increases from 40.00% in the pre-test to 70.00% in the post-test. The following figure demonstrates the findings.



Discussion: Limitations

- Small sample size was a limitation despite the large number of potential participants invited to participate. Although there were sixty-five anesthesia providers from Memorial Regional Hospital invited to participate, five CRNAs completed the pre-test, and the post-test.
- After the educational module was launched, anesthesia providers were reminded twice via email to participate, and the window to participate was one month long.
- The online modality of the educational module also contributed to this QI project's limitations since the project was asynchronous and completed entirely online.
- QI project would have benefited from a live presentation format in efforts to improve recruitment.
- Another limitation of this QI project was the inclusion of one hospital facility. Potential factors to mitigate limitations are to address issues with recruitment, allow for expansion of participation to other sites, and extend the period to participate.

Recommendations for Practice Change

Anesthesia is constantly evolving, and new technological development is at the forefront of the process

The smart glasses have been suggested to improve patient care and safety in the complex anesthesia realm because the technology affords the provider mobility, judicious access to information, and hands-free interaction.

The potential of this new wearable intelligent technology is astounding; the device is portable, easy to use, and straightforward.

Research also shows that the innovative glass technology can aid novices in successfully securing an airway and assist in ultrasound-guided cannulation of an artery or central vein as it gives the user a direct view of the ultrasound machine without the user having to shift the head or change their view.

The glasses also enable users to share what they see with people and other users in other physical places

Conclusion

- The data showed that the QI project increased anesthesia providers' knowledge and attitudes.
- The findings appreciated in this QI project can trigger further research considering using the smart device to secure the patient's airway, intra-operative vital sign monitoring, multi-patient monitoring and ultra-sound guided regional techniques, and arterial and central line cannulations.
- Current research is in its early stages, and there is a need for further research on the benefits of smart glass during the administration of anesthesia.
- The results of this QI project offered valuable insight into how anesthesia provider knowledge and attitudes are affected by an educational module considering the use of the smart glass technology as an adjunct in the administration of anesthesia.
- The findings assumed a positive relationship; anesthesia provider knowledge of smart devices and benefits to practicing, inclination to utilize the smart device increased, and overall attitudes improved

Thank You and Acknowledgements:

- DNP Advisor: **Dr. Anne B. Miller, DNP, CRNA, ARNP**
- DNP Clinical Mentor: **Dr. Kavan Clifford, MD, PHD**
- **Florida International University's DNP in Nurse Anesthesia Program and Chair**
- Research Participants: **Envision Physician Services/Memorial Regional Hospital Anesthesia Providers**
- Research Facility: **Memorial Regional Hospital and Envision Physician Services**
- FIU's Dean of Nursing: **Dr. Jorge Valdes, DNP, CRNA, APRN, FAANA**
- Symposium Guests: Everyone attending this DNP symposium

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Appendix G: QI Project Disseminated Education Module

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FIU

An Educational Module Utilizing Smart Glass Technology as an Adjunct During Anesthesia and Procedural Tasks to Decrease Medical and Human Errors in the Perioperative Period

Mikke-Ann Tracey, BSN, RN
Ann B. Miller, DNP, CRNA, APRN

LEARNING OBJECTIVES

From this quality improvement project, the participant will:

Describe	Describe the the smart glass technology.
Discuss	Discuss the different perioperative use of the smart glass technology.
Understand	Understand the benefits of the smart glass technology as as adjunct in the provision of anesthesia.
Formulate	Formulate ways in which the smart glass technology can improve patient safety by decreasing medical and human errors.

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BACKGROUND OF THE PROBLEM

FIU

- Human factor problems associated with patient monitors have been extensively documented in the literature
- Monitors are often awkwardly positioned outside the provider's view in the operating room
- The chief concern is that the anesthesia provider may miss important events on the monitor when their attention is overloaded during busy periods.
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BACKGROUND OF THE PROBLEM

FIU

- Patients requiring anesthesia today often present with complex comorbidities necessitating extensive vital sign (VS) monitoring.
- Peripheral arterial catheterization is difficult in small pediatric patients, currently the first attempt success rate of radial arterial catheterization by well skilled personnel is 48 to 83% with ultra-sound (US) guidance.
- One of the biggest obstacle for the anesthesia provider is the constant shifting of attention from the patient to the VS monitors/US screen while performing a task or procedure.
- For the novice provider achieving competency in intubation is increasingly difficult, with recent studies reporting first time success as low as 20 to 24%
- The preceptor is unable to see what the novice provider sees complicating the learning process.
- Information about the airway assessment and tracheal intubation is currently communicated verbally or in writing.

Scope of the Problem

- Patients still suffer difficulties despite drastic improvement in anesthesia
- 44% of adverse events that resulted in patient harm were preventable.
- Preventable anesthesia-related adverse events range between 50% and 60%.
- 98.4% of pediatric, obstetric and cardiothoracic anesthesiologists reported work related musculoskeletal pain.
- The goal of this quality improvement project is to improve anesthesia provider vigilance, decrease anesthesia-related complications, and ensure that each patient has a safer surgical anesthetic experience.

FIU

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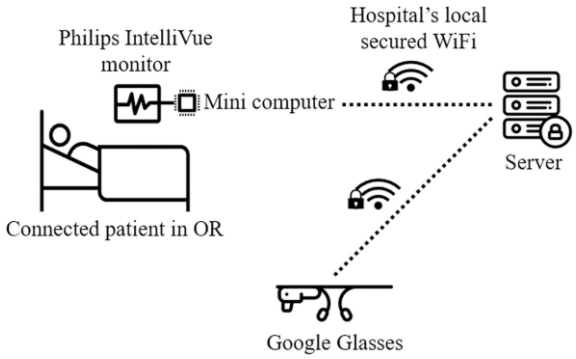
The use of SG by the anesthesia provider during procedures decreasing head and eye shifting from the patient to the monitors, thus improving the anesthesia provider ergonomics.

OVERVIEW OF TECHNICAL SET-UP



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Proposed Quality Improvement via Educational Intervention

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- Bridging the knowledge to practice gap
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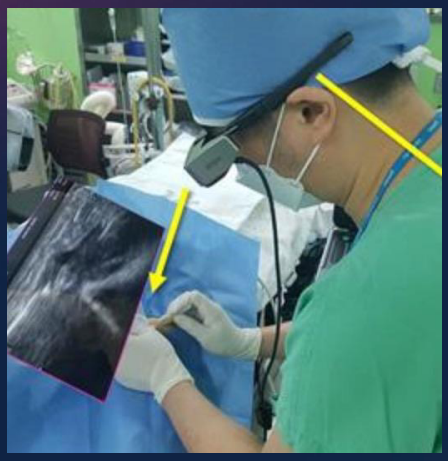
Smart Glass Technology Use



- The SG technology allows anesthesia providers to continuously monitor patients VS intraoperatively
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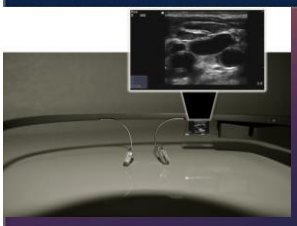

Smart Glass Technology Use

- SG aids peripheral venous access among pediatric patients via ultrasound technology.
- Smart glasses can also improve success for radial arterial catheterization among pediatric patients.
- Decrease procedure time and improve ergonomics in regional anesthesia.
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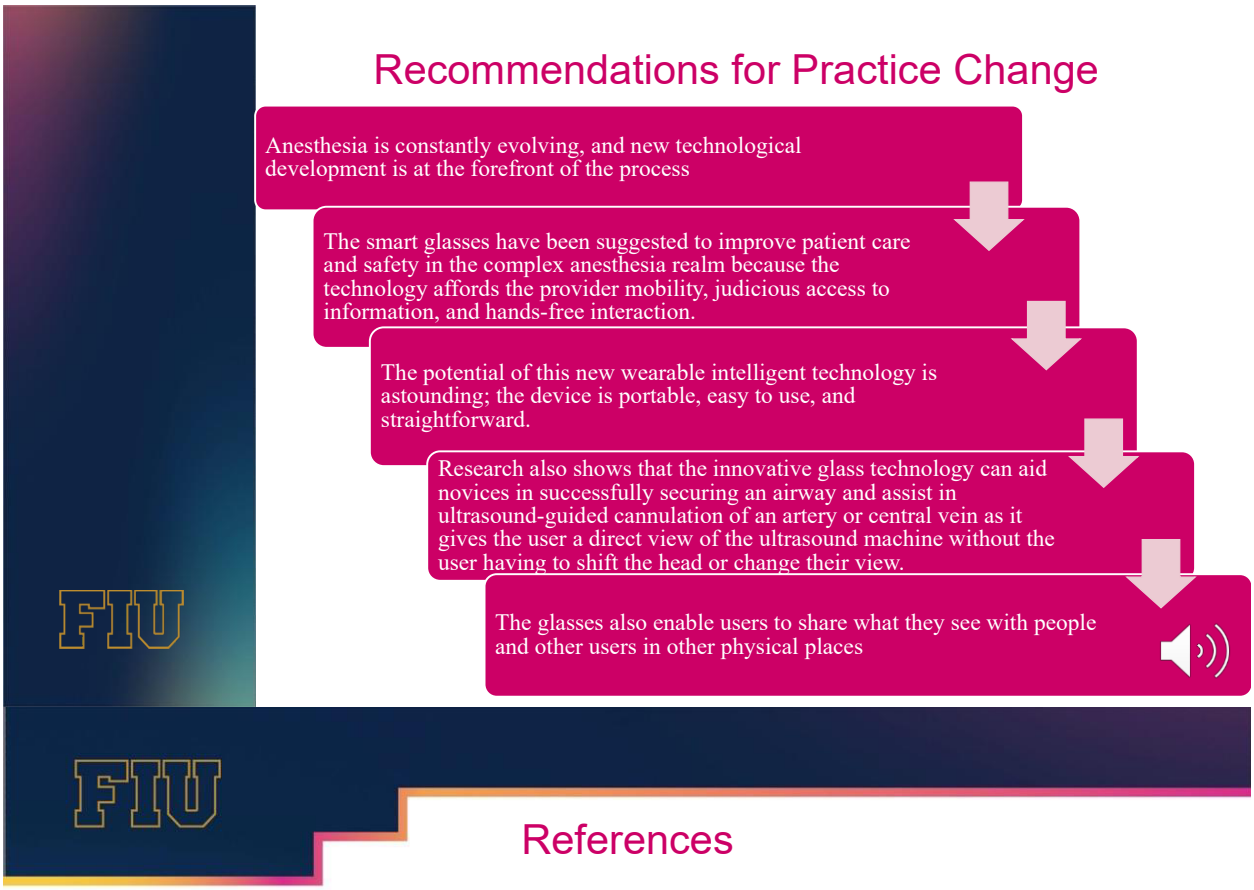

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