Student and Trainee Poster Presentation

A Low-Cost Handheld Imaging and Treatment Platform for Fluorescence-Guided ALA-PDT in Syngeneic Oral Cancer Models

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Oral cancer accounts for approximately 2% of all cancers worldwide, and early detection and treatment remain critical for improving patient survival. Clinical studies from our group have demonstrated the therapeutic efficacy of 5-aminolevulinic acid (ALA)-based photodynamic therapy (PDT) for oral premalignant and malignant lesions, with photosensitizer photobleaching emerging as a potential predictor of treatment response. PDT involves administration of a photosensitizer followed by light irradiation, resulting in the generation of reactive molecular species that induce tumor cell death and can stimulate antitumor immune responses.

In this study, we evaluated a low-cost handheld device capable of both PDT light delivery and fluorescence imaging of protoporphyrin IX (PpIX) before, during, and after treatment. Using syngeneic orthotopic and subcutaneous oral cancer models, we investigated the relationship between PpIX photobleaching, treatment response, and immune modulation. In the orthotopic model, fluorescence imaging demonstrated that intratumoral PpIX accumulation could be regulated by the drug-to-light interval (DLI). Variations in PpIX levels were associated with differences in treatment-induced necrosis and changes in local immune cell populations. In the subcutaneous MOC1 model, PpIX fluorescence enabled accurate delineation of tumor margins, assessment of photobleaching, and facilitated precise confinement of the irradiation field during PDT. Across both models, ALA-PDT resulted in delayed tumor progression and partial improvements in survival.

Collectively, these findings demonstrate the utility of fluorescence-guided ALA-PDT and PpIX photobleaching monitoring in preclinical oral cancer models. The ability to noninvasively quantify photosensitizer accumulation and treatment response provides a foundation for optimizing PDT protocols and supports future investigation of ALA-PDT in combination with immunotherapeutic strategies, including immune checkpoint blockade.

AI-Assisted Fluorescence Kinetic Analysis for Rapid Quantification of Viral Loads

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Rapid and quantitative viral nucleic acid detection is important for point-of-care diagnostics, but conventional endpoint fluorescence readouts often require longer reaction times and provide limited quantitative resolution. Here, we present an AI-assisted fluorescence kinetic analysis approach for rapid viral load quantification of HPV16 and HSV-2. Time-series fluorescence images were collected during nucleic acid amplification/detection reactions at defined target concentrations, including negative controls. Instead of relying on a single endpoint signal, the model learns dynamic fluorescence features from early kinetic patterns to predict target concentration. This workflow integrates fluorescence image acquisition, region-of-interest extraction, and machine-learning-based regression/classification to estimate viral load from short time-course data. The approach was evaluated using HPV16 and HSV-2 datasets across multiple concentration levels and demonstrated the potential to distinguish negative, low-positive, and higher viral load samples based on fluorescence kinetics. By using temporal image information rather than endpoint intensity alone, this method may shorten assay interpretation time and improve quantitative analysis for rapid molecular diagnostics. Overall, this work supports the development of AI-assisted, imaging-based tools for fast and accessible viral load quantification in point-of-care settings.

Advancing Global Access to Laparoscopic Surgery: Current Practice, Challenges, and Evaluation of a Low-Cost Laparoscope in a Porcine Model

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Background. Uptake of laparoscopic surgery in low- and middle-income countries (LMICs) has been slow due to various barriers. This study examines the performance, complications, and challenges associated with laparoscopic surgery across multiple countries while evaluating the safety and feasibility of a low-cost laparoscope in a porcine model.
Methods. Forty-one surgeons from seven countries completed a 12-question survey on laparoscopic outcomes and challenges, with data collected from April 2021 to February 2023. Additionally, surgeons at Duke University evaluated a low-cost laparoscope in a porcine model by performing stapled bowel resection, intracorporeal knot tying, and cholecystectomy, comparing performance with the standard-of-care (SOC). Vital signs, complications, task completion times, and post-procedure feasibility surveys were analyzed.
Results. Thirty-six surgeons reported 198 laparoscopic cases across multiple countries, highlighting differences in patient characteristics, blood loss, technical challenges, and conversion rates between high-income countries and LMICs. Four major barriers in LMICs were identified: limited resources, equipment maintenance, complex pathology, and inadequate surgical training. In the porcine evaluation, five surgeons completed 45 laparoscopic tasks with the low-cost laparoscope and the SOC. There were no significant differences in vital signs or completion times for bowel resection and cholecystectomy, although intracorporeal knot tying was faster with the SOC. Surgeons rated the low-cost device favorably for ergonomics and fog resistance, preferred it over an open approach, and reported willingness to use it for laparoscopic procedures outside their routine practice.
Conclusion. Laparoscopic surgery faces greater technical and resource-related challenges in LMICs than in high-income countries. A low-cost laparoscope demonstrated

comparable safety and feasibility to SOC in a porcine model, supporting its potential to support laparoscopy in LMICs.

Esophageal Cancer Diagnostics Deployable in Resource-Constrained Settings through a Patient-to-Answer Platform

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Early cancer detection is critical to improving clinical outcomes, and point-of-care diagnostics can accelerate diagnosis for patients with limited access to centralized hospitals and laboratories. This need is especially urgent for esophageal cancer, which causes more than 600,000 new cases and 500,000 deaths annually, with esophageal squamous cell carcinoma (ESCC) disproportionately concentrated in eastern and southern Africa. Patients with progressive dysphagia in these regions often travel long distances for intrusive evaluation, weeks-long pathology, and costly follow-up care, underscoring the need for a same-day diagnostic test using minimally intrusive esophageal sampling. DNA methylation biomarkers are promising for early cancer detection because epigenetic changes can appear early in tumorigenesis, but conventional quantitative methylation-specific polymerase chain reaction (qMSP) workflows still require multistep sample

processing, DNA purification, bisulfite conversion, and qMSP by trained personnel in centralized laboratories. To address these barriers, we introduce the Automated Cartridge-based Cancer Early Screening System (ACCESS), a portable, briefcase-based, patient-to-answer platform that integrates swallowable sponge-based esophageal sampling, battery-powered sample preparation, and automated droplet magnetofluidic methylation analysis. ACCESS combines a portable centrifuge for milliliter-volume cytology samples, an enclosed five-channel thermoplastic assay cartridge, and a point-of-care analytical instrument with automated magnetic bead transfer, heating, and fluorescence imaging. The full workflow is completed in approximately four hours with only two brief manual steps. We implemented assays for four ESCC methylation biomarkers (C1ORF70, SKOR1, JPH4, PPFIA3) and housekeeping control gene ACTB. Using sponge-collected esophageal samples from 25 ESCC patients and 25 normal esophagus patients from Mbarara, Uganda, methylation indices measured by ACCESS showed concordance with a manual benchtop standard assay. Receiver operating characteristic analysis supported strong diagnostic discrimination, with the selected three-marker model achieving 0.880 sensitivity and 1.000 specificity. These results demonstrate ACCESS as an amenable epigenetic diagnostic platform for same-day esophageal cancer detection in resource-constrained settings and potentially other malignancies worldwide.

Patient-Reported Comfort and Preference for ATUSA Compared with Hand-Held Ultrasound at Vanderbilt University Medical Center

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Portable automated three-dimensional breast ultrasound (ATUSA) is an emerging breast imaging technology that acquires standardized whole-breast volumetric images with less operator dependence than conventional hand-held ultrasound (HHUS). Traditional HHUS remains an essential component of breast imaging but requires real-time scanning by trained personnel, which can introduce variability in image acquisition and limit scalability across practice settings. By decoupling image acquisition from interpretation and standardizing the examination, ATUSA may offer advantages for broader diagnostic imaging deployment.

As part of a parent study at Vanderbilt University Medical Center (VUMC) evaluating ATUSA technology, early patient-reported outcomes were examined in women presenting for diagnostic breast imaging secondary to a palpable concern or focal pain. A total of 124 participants were enrolled and completed patient feedback surveys were available for 95

women. Surveys used a 3-point Likert scale focused on acceptability, comfort, and communication.

Patient responses were favorable overall. The examination was rated acceptable by 90 of 95 respondents (94.7%; 95% CI, 88.1–98.3). Only one participant reported the examination as rough, while 94 of 95 (98.9%; 95% CI, 94.3–100.0) disagreed that the exam was too rough. Ratings related to explanation of the study and opportunity to ask questions were similarly positive, supporting smooth integration into the clinical environment.
When asked to compare imaging methods, 55 of 91 women (60.4%; 95% CI, 49.6–70.5) reported no preference. Among those expressing a preference, 69.4% (N=25) preferred ATUSA over HHUS (95% CI, 51.9–83.7; p=0.029). Comments from participants referenced greater comfort, less pain, and a calmer overall experience as reasons for preferring ATUSA. Women preferring HHUS cited familiarity.
Early VUMC data suggests that ATUSA is well tolerated and there was no evidence of patient-related resistance to the technology. Favorable patient experience may be an important contributor to future multi-site implementation efforts and broader adoption of scalable breast imaging pathways.

Point-of-care cervical cancer screening test targeting eight high-risk HPV types

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Almost all cases of cervical cancer are caused by high-risk human papillomavirus (HPV) and occur in resource-limited settings. Implementing World Health Organization-endorsed HPV DNA screening is a critical step in cervical cancer elimination. However, DNA testing usually requires expensive equipment and trained personnel, which are often unavailable in resource-limited settings. To fill this gap, we developed a low-cost point-of-care HPV DNA test based on loop-mediated isothermal amplification (LAMP). It detects the eight most oncogenic HPV types accounting for approximately 90% of cervical cancer cases. Additionally, we utilize extraction-free sample preparation adding sample lysate directly to the LAMP reagents, which allows for simpler equipment and minimal user steps compared to traditional DNA testing methods.

We tested 41 provider- or self-collected samples in Houston, Texas using the LAMP test

and compared the results to GeneXpert HPV, a PCR-based reference test. Of the 31 GeneXpert HPV-positive samples, 30 were positive with LAMP (one invalid). All GeneXpert HPV-negative samples matched with LAMP.

We also conducted usability studies for the HPV LAMP test in a kit-like format with eight participants. The kit includes dropper bottles for simple liquid handling and minimal user steps. Participants were given a printout of instructions on how to run the test, independently ran it, and completed the system usability scale (SUS). The average SUS score was 77.8, which falls into the “good” usability category.

Next steps include lyophilizing the LAMP reagents for long term shelf stability and conducting additional usability studies with participants with no lab training. With future work, this HPV LAMP test has the potential to expand access to cervical cancer screening in resource-limited settings.

Programmable CRISPR-Mediated Gold Nanoparticle Adhesion for Instrument-Free, Visual Colorimetric Detection of HPV-16 DNA

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Cervical cancer remains a leading cause of cancer mortality among women in resource-limited settings, where access to complex, electricity-dependent molecular diagnostics is severely restricted. Here we present a new CRISPR-Cas12a signal transduction mechanism that harnesses programmable hydrophobic adhesion of streptavidin-coated gold nanoparticles (AuNPs) functionalized with Cy5-ssDNA-biotin probes. In the absence of target HPV-16 DNA, densely packed hydrophobic Cy5 domains on the AuNP surface induce strong adhesion to ordinary polypropylene tube walls, producing a clear supernatant. In the presence of HPV-16 DNA, activated Cas12a trans-cleavage disrupts this adhesion, releasing the AuNPs into a visibly red colloidal suspension and enabling dual-mode naked-eye colorimetric detection without the need for complex chemistries such as linker-based aggregation, pre-functionalization, or extra equipment such as lateral flow strips or imaging devices.

When combined with recombinase polymerase amplification (RPA), the single-tube assay achieves a naked-eye limit of detection of 10 aM for HPV-16 DNA and demonstrates 100% concordance with qPCR in a pilot study of 10 de-identified clinical cervical samples.

When coupled with other simple complementary technologies developed in our laboratory, such as our reusable self-contained sodium acetate handwarmer-powered incubator (capable of fully electricity-free incubation at 37–42 °C), this platform becomes a complete, portable, low-cost, power-free point-of-care molecular diagnostic system ideally suited for global cervical cancer screening.

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Programmable Multiplexed Nucleic Acid Detection by Harnessing Specificity Defect of CRISPR-Cas12a

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CRISPR-Cas12a works like a sophisticated algorithm in nucleic acid detection, yet its challenge lies in sometimes failing to distinguish targets with mismatches due to its specificity limitations. Here, the mismatch profiles, including the quantity, location, and type of mismatches in the CRISPR-Cas12a reaction, are investigated and its various tolerances to mismatches are discovered. By harnessing the specificity defect of the CRISPR-Cas12a enzyme, a dual-mode detection strategy is designed, which includes approximate matching and precise querying of target sequences and develop a programmable multiplexed nucleic acid assay. With the assay, 14 high-risk human papillomavirus (HPV) subtypes are simultaneously detected, collectively responsible for 99% of cervical cancer cases, with attomolar sensitivity. Specifically, the assay not only distinguishes HPV16 and HPV18, the two most common subtypes but also detects 12 other high-risk pooled HPV subtypes. To enable low-cost point-of-care testing, the assay is incorporated into a paper-based microfluidic chip. Furthermore, the clinical performance of the paper-based microfluidic chip is validated by testing 75 clinical swab samples, achieving performance comparable to that of PCR. This programmable multiplexed nucleic acid assay has the potential to be widely applied for sensitive, specific, and simultaneous detection of different pathogens.

Quench-free Amphiphilic Fluorescence DNA Probe for CRISPR-based HPV-16 DNA Detection

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CRISPR-based nucleic acid detection has emerged as a powerful platform for rapid and sensitive molecular diagnostics, playing an increasingly important role in the early screening of viral infections. Human papillomavirus type 16 (HPV-16), a high-risk pathogen strongly associated with cervical cancer, poses a significant global threat to women's health. In this study, we developed a novel quench-free amphiphilic fluorescence DNA probe (QFAP) for HPV-16 detection on a paper-based microfluidic device by integrating recombinase polymerase amplification (RPA) with a CRISPR-Cas12a assay.

The QFAP comprises a hydrophobic Cy5 fluorophore head and a hydrophilic single-stranded DNA (ssDNA) tail. Upon recognition of HPV-16 DNA, CRISPR-Cas12a is activated and cleaves the probe, shortening its length and increasing its overall hydrophobicity. This change modulates fluid transport behavior within paper microchannels, producing a distance-based fluorescence readout that eliminates the need for quencher molecules. Paper-based microfluidic devices were designed using SolidWorks and fabricated on Whatman Grade 1 paper by wax printing in a thermometer-shaped geometry. PCR adhesive films were applied to both sides to seal and define the microfluidic channels. QFAPs and the deglycerolized RPA/CRISPR detection system were designed and optimized in tube. The reaction products were introduced into the paper-based microfluidic devices. After 10 minutes, fluorescence images were acquired using a ChemiDoc™ MP system, and fluorescence transport distances were quantified using ImageJ. Analytical sensitivity was determined using serial dilutions of HPV-16 DNA. Clinical feasibility was further evaluated using 15 patient swab samples.

Lower target concentrations result in less cleavage and correspondingly longer fluorescence transport distances. The QFAP-based detection system demonstrated a limit of detection of 10 fM for HPV-16 DNA. Clinical validation showed that 5 samples were positive and 10 were negative, in complete concordance with quantitative PCR (qPCR) results. This QFAP-based RPA/CRISPR system offers a simple, reliable, and sensitive

solution for point-of-care HPV-16 detection.

Risk factors for product quality failures in anticancer products

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From April 2023 through July 2025, 451 unique lots of anticancer medicines were collected in Kenya, Malawi, Cameroon, and Ethiopia and were assayed by high-performance liquid chromatograph. One in five of these products failed assay. We are now attempting to identify factors that can predict the risk of quality problems for chemotherapy products.

Since over 80% of the manufacturers identified in our study were from India, we compared our HPLC pass/fail data with Indian regulatory findings, focusing on manufacturers where we tested at least two lots of chemotherapy products. Our working hypothesis was that Indian manufacturers “in the database” (because they had previously manufactured at least one product that failed regulatory standards in India) would be riskier than Indian manufacturers that were not in the database. We analyzed a total of 313 unique lots of chemotherapy products that were stated to be made by 29 Indian manufacturers.

Manufacturers that were in the database had a higher average risk of failure (31% of lots failed) when compared to manufacturers that were not in the database (16% of lots failed). The correlation between failure of assay for anticancer drugs, and previous regulatory violations, often for other types of drugs, suggests that errors in good manufacturing practice rather than errors in shipping or storage of the product are a key underlying risk factor. However, other risk characteristics are clearly needed to accurately predict which products are most likely to fail assay.

The KeyScope: The Key to Increasing Access to Laparoscopic Surgery

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Minimally invasive laparoscopy is the standard of care for most surgeries performed in the abdominal cavity due to a significant reduction in surgical comorbidities compared to open surgeries. Despite its established benefits, laparoscopy remains inaccessible in many low-

income communities due to the high initial cost of equipment, ongoing maintenance costs, shortage of biomedical technicians, and limited sterilization facilities. To increase access to laparoscopic surgery, we are developing a suite of reusable, low-cost, durable laparoscopes called the KeyScope. Specifically, we are designing a 0° KeyScope and 30° KeyScope, which will enable surgeons to see different fields of view within the abdomen. Rather than using expensive and fragile fiber optics, the KeyScope utilizes light-emitting diodes (LEDs) and a color-complementary metal-oxide-semiconductor (CMOS) detector at the tip of the device's probe, which significantly reduces cost and complexity. Here we describe the iterative design and testing of the 0° and 30° KeyScopes. Significant improvements were made to the KeyScope design to increase image quality, performance, and durability. The most recent KeyScope version exhibited significantly increased brightness compared to the previous version, rising from 243 klux to 676 klux at a 3 cm working distance, thereby fully illuminating the abdominal cavity. Further, the KeyScope demonstrated sufficient durability and longevity, as it can operate for over 1,000 hours without a significant decrease in LED brightness or camera functionality. Further, the KeyScope withstood 500 N of force without any change in function. The 30° KeyScope achieved similar resolution to the 0° KeyScope (115.6 μm vs 111.3 μm, respectively, at 5 cm working distance) even with the additional space limitations associated with the 30° angled tip. Overall, the improvements in the KeyScope designs results in increased illumination and strong durability, indicating devices are ready for clinical translation to low-income communities.