Protocol Title: Exploring new and next generation ultrasound technologies for medical education, patient care, and new indications

Protocol Project Number: RP0509

Protocol Date: October 12, 2017

Principal Investigators:

Michael V. Knopp, MD, PhD
Professor, Department of Radiology
Novartis Chair of Imaging Research
Distinguished University Scholar
Vice-Chairman of Research
The Ohio State University Wexner Medical Center
395 West 12th Avenue, Room 430
Columbus, Ohio 43210
Phone: (614) 293-9998
Fax: (614) 293-9275
E-Mail: knopp.16@osu.edu

Study Team:

Michael V Knopp, MD, PhD	principal investigator
Melanie Hughes	informed consent, scheduling, administration
Michelle I. Knopp, (MED 4)	informed consent, data acquisition, data processing
Sarah Spaulding	informed consent, scheduling, data management
Katherine Binzel, PhD	informed consent, data acquisition, data processing
Chadwick L. Wright, MD, PhD	informed consent, data acquisition, data processing
Melanie U. Knopp	informed consent, data acquisition, data processing
David Bahner, MD	informed consent, data acquisition, data processing
Gayle Gordillo, MD	informed consent, data acquisition, data processing
Samantha Kisare	informed consent, data acquisition, regulatory
Sarah Herald	regulatory management

I. Overview

Ultrasound (US) is an enabling, non-invasive, widely used clinical imaging technology that has evolved from very bulky equipment towards smaller and more portable systems in the last three decades. In 2015, a new technology milestone was achieved with the first commercial introduction of a smart app based device (Android based smart phone or tablet) utilizing a mirco-usb connected ultrasound probe that received 510K FDA approval. This extreme miniaturization has the potential to be disruptive and should enable new, refined, or modified approaches to use such an ultrasound system in healthcare.

Ultrasound imaging requires three essential components:

1. An **ultrasound transducer** that emits and receives the ultrasound waves - the app based system currently has two different transducers available, a linear array (straight contact area) for near field imaging such as vessels or subcutaneous structures and a curved array, for deeper tissue ultrasound wave penetration such as abdominal imaging

2. The need for a contact medium such as **ultrasound gel** to create a continuous sound medium that is applied on the subject skin at the location of the desired anatomy. The gel is non allergic, non-toxic, water soluble, and readily wipes off

3. A **display and recording device** to visualize the ultrasound reflections and save the reconstructed images as either DICOM or movie files

Surprisingly, no clinical evaluation studies exploring new, refined, or modified approaches have yet been published using this ultra-portable technology, so that we decided to initiate this Phase I feasibility assessment study.

Within this study we want to explore ultrasound in the following populations:

A) Use of new ultra-portal ultrasound systems with **patients** in the clinical setting
   1. To compare to standard of care ultrasound studies to allow for intra-individual comparison
   2. As an extension of the physical exam for functions such as a virtual stethoscope by practitioners and trainees including medical students (not intended to replace clinical ultrasound)
   3. To investigate new applications of miniaturized ultrasound such as supporting the placement of intravenous access for delivery (infection / infusion) of imaging pharmaceuticals and/or pharmaceuticals or in wound care as complementary to standard of care treatments
B) Examine how new generations of US systems handle from the perspective of personnel that typically uses such equipment such as **physicians, students, and ultrasound technologists** in the form of questions, interviews, online surveys, and free hand on preferences and experience
C) For practice and understanding application of new generation ultrasound systems in **volunteer populations** outside of patient care

II. Objectives

Aim 1: Evaluate feasibility of use of a new app-based ultra-portable, ultrasound system in the clinical setting

Aim 2: Review image quality and consistency of quality

Aim 3: Examine the use of new app-based ultra-portable ultrasound as an extension of the physical exam and implementation into medical education

Aim 4: Determine potential clinical applications, opportunities, and limits

Aim 5: Perform intra-individual comparison to current clinical use ultrasound device

Aim 6: Exam the perception and integration of new, ultra-portable ultrasound systems

Aim 7: Determine the potential educational value to medical student experience

III. Background and Rationale

Ultrasound is a non-invasive, effective imaging methodology that is being used for many applications. The clinical availability of an ultra-portable app-based ultrasound system is a technology leap that has the potential to completely change the way ultrasound is used.

Integrating the technology into the clinical setting could make ultrasound as vital as palpation during a physical exam.

Medical schools across the country have started including ultrasound in the first two years of medical school. In fact, Loma Linda University has demonstrated improved standardized patient interview exam scores with the integration of ultrasound into the curriculum suggesting medical educational value in expanding implementation of ultrasound in improving physical exam skills of practitioners.

Our team has extensive experience in exploring, developing, assessing and validating new medical imaging technology. This effort is intended to investigate and explore different use cases and acquire preliminary data to design specific future clinical trials (Phase III and Phase IV).

It also must be highlighted that such innovative uses when well designed and integrated into appropriate diagnostic and care concepts might also be highly cost effective and practical in clinical use and have the potential to improve medical education.

Without a rigorous exploration and preliminary data, we cannot systematically develop and validate new disruptive concepts; this is the essential basis for this clinical trial.

As ultrasound is minimal risk and non-invasive, the subjects participating will not experience any additional risks. They will only be asked to donate time for the additional use of the ultra-portable ultrasound system and to potentially grant permission for us to review their health record to compare scans conducted with new, ultraportable technology to that of standards of clinical care.

Figure 1: Ultra-portable ultrasound system (Lumify, Philips) that is based on an Android app and connects via a micro USB adapter. It can be connected to current generation smart devices such as the Samsung Tab A tablet or the Samsung Galaxy Phone S6. All functionality of the smart device remains such as the ability to chromecast to a larger TV or display. The ultrasound probe can readily fit in a coat pocket.

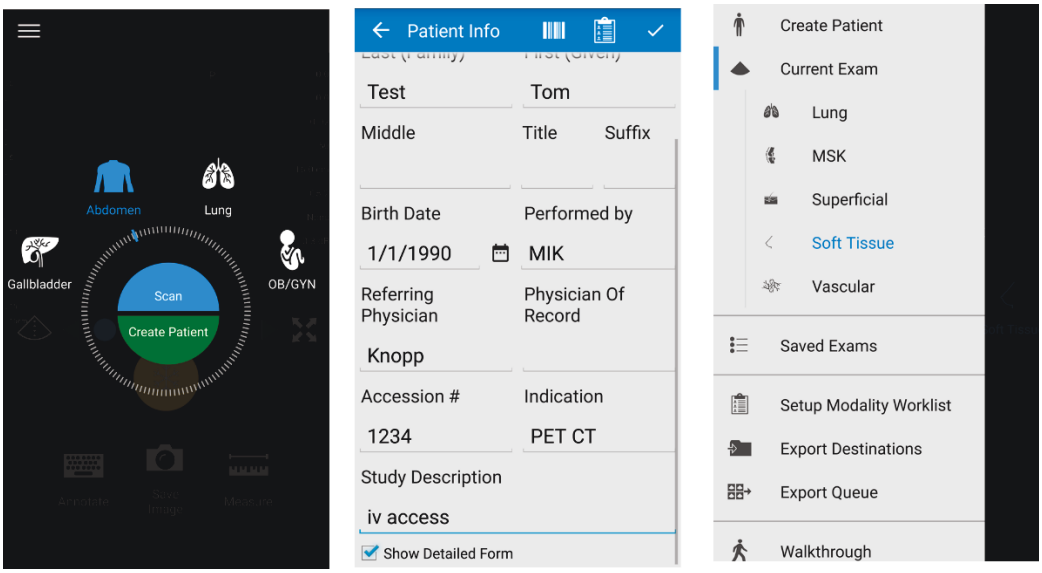

Figure 2: Display screens of the app are designed for ease of use while all logistic aspects of recording a patient exam are supported. Patient information can be entered or even a bar code scan can be used to pull in HIS or RIS information.

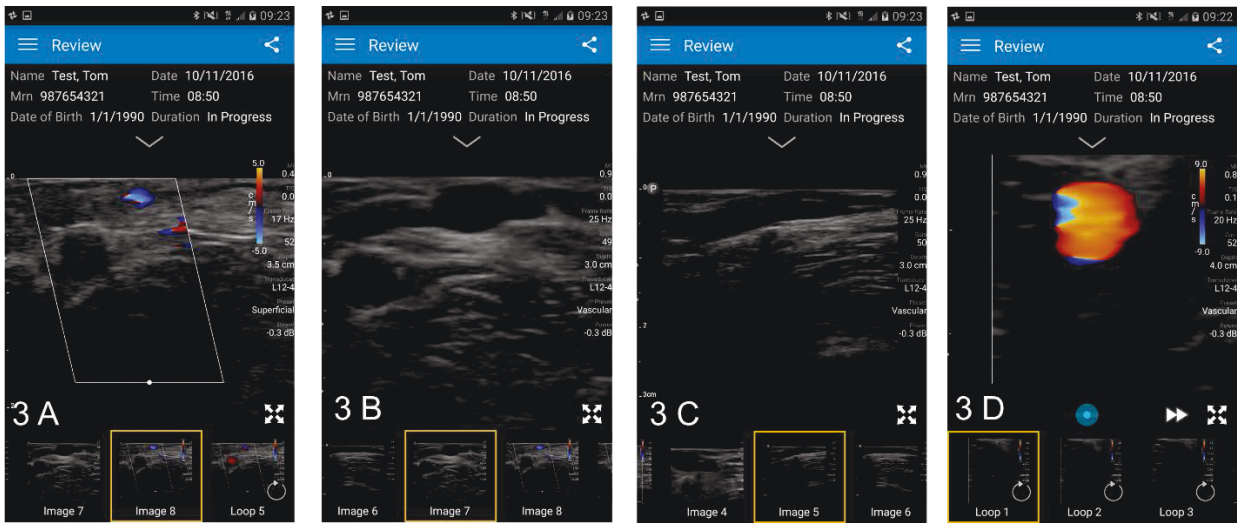

Figure 3: Screenshot images from a smartphone connected to the linear array ultrasound probe. (A) with the flow coding activated, the subcutaneous vein can be readily identified, and flow can be confirmed. (B-C) show axial and sagittal views of a sub-cutaneous vein in the antecubital fossa. The staff preparing an IV can rapidly screen the venous situation in the crook of the elbow or if needed other anatomical regions. (D) shows the color Doppler coding of an arterial vessel that can readily be identified as such.

IV. Procedures

Research Design

This is a Phase I study to assess feasibility. There will be no impact on clinical care based on this study. The ultrasound system is FDA approved and could be used for clinical care independent of this research study.

When a subject receives an ultrasound examination as part of standard of care or within another clinical research trial, such an examination may serve for an intra-individual comparator examination between conventional and new, ultra-portable ultrasound imaging. Patients will be identified in the clinical setting when appropriate and will be appropriately approached for consent for a combination of ultrasound with the physical exam, for medical student education, IV access, and novel application. Patients will be enrolled and accounted for in the appropriate sub-population.

Additionally, to understand the impact of ultraportable ultrasound, survey tools will be used to understand the workflow and clinical care applications and integration of these devices. All staff and student members will be appropriately consented; however, we anticipate that this portion of the study will be minimal risk.

Finally, the volunteer population will allow us to practice the use of this equipment and understand the limitations and applicability. The results will be the images acquired as well as surveys from the volunteers and those performing the scans, who will be enrolled in the staff population of this study.

A. Sample

Patient Population

We plan to enroll up to 450 subjects in this clinical feasibility exploration. We do not expect to enroll more than 150 subjects for any specific question.

Intra-individual comparison to conventional ultrasound imaging (150 subjects)

Assessment of utility of new, ultraportable ultrasound technology for medical student education and/or in combination with a physical examination (150 subjects)

Assessment of utility of new, ultraportable ultrasound for IV access (100 subjects)

Assessment of utility of new, ultraportable ultrasound for novel applications (50 subject)

Staff (Physicians, Ultrasound technologists) and Student Population

Staff working in imaging related healthcare environment and medical students will be enrolled to study the perception, advantages and disadvantages, and possible applications in a variety of settings. We plan to enroll up to 150 subjects to study the impact of new, ultraportable ultrasound on workflow and clinical care. Medical students and practitioners conducting research ultrasound imaging in the patient or volunteer population described above will be enrolled in this portion.

Volunteer Population

We plan to enroll up to 150 subjects who will be scanned using the ultraportable ultrasound in the feasibility exploration to develop best practices for this equipment, exam the feasibility and potential indications, and examine implementation concerns of ultraportable ultrasound.

Inclusion Criteria

- Male and female subjects or patients greater than or equal to 18 years of age.
- Patients who are capable of giving informed consent

Exclusion Criteria

- Prisoners.
- Participants incapable of giving informed consent, even if they have a power of healthcare attorney who is clearly identifiable and available for the consenting process

B. Measurement / Instrumentation

All devices will be operated according to the manufacture instruction manual. All ultrasound devices are FDA approved and will be used within the manufacture device settings.

Comparison of ultraportable ultrasound with standard of care will be qualitative as well as quantitate where appropriate. A review of the new, ultraportable ultrasound images will be conducted by a trained reader/viewer to compare quality of images, positioning of the patient, time required for the study, limitations, and ability of capture appropriate anatomy.

All patients consented to this study independently of what arm, will be asked to fill out a survey about their experience to assess appropriate use of the technology as well as to understand patient perception of the increased integration of ultrasound into the clinical environment.

All operators of the ultraportable ultrasound will be asked to fill out a survey for each scan they conduct to collect data about the operator experience, settings of use, and implementation into the clinical setting.

All survey tools will be available in printed as well as online format through a secure exchange. Subjects will be identified only by their coded ID and not identifiable information.

Measurements will include quantitative satisfaction scores, qualitative comments, time required for scans, experience, and location of scan to help guide further development and implementation.

C. Detailed study procedures

Administration of informed consent

Informed consent may be given at any time after the subject has had appropriate time to read the informed consent form and ask and receive answers to any questions.

We prepared a training video for the trial staff to see how we would like to have the informed consent administered to all aspects of GCP, and applicable further guidelines will be appropriately reflected.

The informed consent form may be given ahead of time or at the time just prior to start of the participation.

Withdrawal from the study

The subject can withdraw at any time from the study. At the time of a withdrawal, the subject may be asked if he or she wants to do a complete withdrawal or just wants to stop further participation and allows use of the already gathered data.

Compensation for participation in the research

Subjects will not be compensated for their participation in this study; they will be donating their time.

Location of performance of research

While the patient related research efforts will be exclusively performed at The Ohio State University Wexner Medical Center or its affiliated facilities, staff and volunteers may complete survey tools at any location of their preference.

Staff and volunteer testing may be performed at any appropriate location and/or environment that is conducive to the performing of such testing at The Ohio State University.

Ultrasound scanning

The effective ultrasound imaging approach will vary by the specific situation that is detailed below:

Patient Population

We plan to have patients involved four in different scenarios, all after informed consent has been given and documented.

Patient having a standard of care US and participates in the comparator assessment using the new or ultra-portable ultrasound technology.

In this situation, the patient will have an investigational ultrasound with the new technology either before or after the performance of the standard of care ultrasound examination. The sequence is not important and therefore can be adapted to what is most convenient for the patient or to the time management of the patient's schedule. The investigational ultrasound may include any anatomic area to which the patient has no objection to be scanned including but not limited to the same anatomic area scanned as part of the standard of care ultrasound examination.

In addition to the investigational ultrasound examination, the patient will be given a questionnaire to provide feedback from his or her perspective.

Patient having a physical examination by a medical student, resident or physician.

In this situation, an investigational ultrasound with the new technology may be performed as an extension of the physical examination. This ultrasound will not be used for any medical care decisions and does not replace any medically indicated ultrasound examination. It is solely performed for investigational purposes to assess the feasibility and potential utility of an ultra compact ultrasound technology.

In addition to the investigational ultrasound examination, the patient will be given a questionnaire to provide feedback from his or her perspective.

Patient requiring vascular access

In this situation, investigational ultrasound will be performed for the sole purpose of identifying vascular structures in the area of desired vascular access. The typical scenario will be a technologist or other healthcare provider performing the vascular access procedure who would use the new ultrasound technology to identify vessels as well as to visualize if flow can be detected.

In addition to the investigational ultrasound examination, the patient will be given a questionnaire to provide feedback from his or her perspective.

Patient has a medical diagnosis and within this clinical trial we will use and evaluate the new ultrasound technology regarding its potential of enabling novel application. This ultrasound will not be used for any medical care decisions and does not replace any medically indicated ultrasound examination. It is solely performed for investigational purposes to assess the feasibility and potential utility of an ultra compact ultrasound technology to help in management of the patient situation.

In addition to the investigational ultrasound examination, the patient will be given a questionnaire to provide feedback from his or her perspective.

Staff Population

Any operator of the new, ultraportable ultrasound technology will have the option to enroll in this trial, as we want to also assess the experience and perception of the operator. The operator of the ultrasound device for the purpose of this investigational assessment may be technologists, physicians, fellows, residents, medical students, nurses, physician extenders, or other healthcare or health technology professionals or students in training of those professions.

Before any operator will be allowed to use the investigational ultrasound system, they will need to go through a training session in which they demonstrate that they have familiarized themselves with the technology and are able to appropriately operate the device. The current user manual of the Lumify ultrasound or other applicable devices will be provided prior to the training session.

The staff operator will have to demonstrate his or her ability to operate the system as well as to document their understanding of this protocol. The completion of this training/review session for the purpose of this clinical trial will be documented in the training log. The training will be performed by the PI or after completion of prior training by a designee.

The Staff will be given a questionnaire to provide feedback from his or her perspective after completion of every ultrasound imaging session.

Other appropriately training staff / physicians will assist the PI in the image review of the recorded images, and the findings will be documented using a survey tool.

Staff has also the option to withdraw from participation of this trial at any time.

Volunteer Population

We plan to have volunteers involved in two different scenarios, all after informed consent has been given and documented.

Participation in a single ultrasound exam session

In this situation, the healthy volunteer will allow the performance of an investigational ultrasound session with the new technology. The investigational ultrasound may include any anatomic area to which the patient has no objection to being scanned. The typically single scan session will take 20 – 30 minutes.

Ultrasound images will be captured that will be reviewed by the PI or experience designee regarding the quality, potential diagnostic use, extent of artifacts or any other observation.

In addition to the ultrasound examination, the participant will be given a questionnaire to give feedback from his or her perspective.

Participation in a multiple ultrasound exams and multiple operator sessions

In this situation, the healthy volunteer will allow the performance of an investigational ultrasound including multiple ultrasound exams and multiple operator sessions with the new technology. The investigational ultrasound may include any anatomic area to which the patient has no objection to being scanned. The typically multiple scan / multiple operator session will take 90 – 120 minutes.

Ultrasound images will be captured that will be reviewed by the PI or experience designee regarding the quality, potential diagnostic use, extent of artifacts or any other observation.

In addition to the ultrasound examinations, the participant will be given a questionnaire to give feedback from his or her perspective.

Survey / Questionnaire tools

The following survey / answer capture tools will be utilized that will be preferentially captured via a web tool on a smart / tablet device or alternatively in paper hard copy. If electronic data capture is used, the captured data will be archived to insure that they can serve as source documents.

- Patient Survey
- Volunteer Survey
- Staff Registration Survey
- Staff Operator Exam Feedback Survey
- Staff Assessment of Imaging Exam Survey

Incidental findings

Anytime an imaging study is preformed, there is some risk that an incidental finding in observed. There will be minimal risk or likelihood in the patient population, as they are already undergoing standard of care ultrasound or physical exams.

The risk or likelihood will be slightly higher in the volunteer population as they will not be receiving standard of care studies. Informed consent form does ask subjects to identify if they would like to be directly informed of an incidental finding and if this finding should be communicated to the health care provider of their choice.

Incidental findings are not intended to be released to patients or subjects at the time of the scan and are part of the reporting survey that will be filled out at the end of each study. These reports will be gathered and reviewed by the PI or appropriate delegates to determine the appropriate level of next steps. The communication will follow the choice indicated on the ICF form.

Data analysis and analytics

As this is an exploratory trial, we have no prior data available to develop a detailed analysis plan. We will perform descriptive statistics and assess relationships between the preferences and observed data gathered from the survey tools and/or noninvasive measurement. We will consult statistical expertise at different phases of data gathering to review data capture and tabulation procedures as well as explore data analysis strategies.

Data sharing

Coded or de-identified data may be shared with other research projects as additional information or for benchmarking observations. Data may be shared for further analysis with research teams at The Ohio State University or outside. The data sharing agreements would be documented and executed prior to sharing of data according to The Ohio State University policies.

De-identified data may be placed in public databases, especially if it is required by funding agencies such as National Institutes of Health, National Science Foundation, and others.

D. Risk, Benefits, Safety, and Confidentiality

Risks

No significant risk is identified for subjects in this study. The largest risk, although still minimal, is an incidental finding. For this study subjects will have the choice if they would like to be informed of an incidental finding. Reporting of incidental findings will be conducted by designated study staff after appropriate consultation and examination of the images by the PI or designee.

Benefits

While there are no direct benefits for subjects in this study, the study hopes to improve the implementation of ultrasound into the clinical setting into the future. This Phase I study aims to examine the feasibility of implementation and the impact on the clinical setting. Additionally, this study hopes to examine the utility and usefulness of ultrasound in medical education and thereby hopes to improve the physical exam skills of clinicians for the future.

Safety Monitoring

No formal safety monitoring will be necessary; however, a regular review of data to identify any concerns from patients and staff will be performed. Any safety concerns or observations will be presented to the PI in a timely manner and addressed in a reasonable timeframe.

Confidentiality of Records

Patient Population

Patient populations will be identified using coded IDs assigned at the time of the signing of the informed consent. From that point forward the patient will only be identified by the coded ID. When clinical data is accessed and retrieved to compare study images to standard of care ultrasound images and report, all data that will be managed and recorded will be coded.

Staff Population

Only for the purpose of identifying a subject regarding participation and potential regulatory follow-up, a single coding identification sheet will be kept. All other data points will be generated in coded data structures.

There will be no linkage of any information regarding participation in this study or any HR documentation. Participation in this study will in no way affect any performance or educational assessment review.

Volunteer Population

Only for the purpose of identifying a subject regarding participation and potential regulatory follow-up, a single coding identification sheet will be kept. All other data points will be generated in coded data structures.

E. Internal Validity

Managing and verifying the internal validity is an important task in this exploratory research program in order to develop the appropriate methodology to be validated in prospective clinical trials.

As there is an opportunity that the ultrasound operator can potentially bias the subject, we will perform training sessions prior to them participating. We will also perform from time to time an observational assessment by a study member participating in the project with the task to observe the ultrasound operator to ensure that no bias or systematic errors occur.

In this exploratory study where we use image and observation-based assessments, we will have to constantly assess the potential sources of systematic errors or bias in order to ensure that we may derive conclusions that warrant generalization to other contexts.

We will assess the different factors impacting internal validity of the data sets we generate. For the specific factors we will address the following considerations:

The following text uses material presented at https://en.wikipedia.org/wiki/Internal_validity and is hereby specifically acknowledged.

Temporal precedence

Potential lack of clarity how one experience may influence a subsequent experience as that might be a cause and effect relationship.

Confounding

A major threat to the validity of causal inferences is confounding. Observations in one variable may relate to another manipulated variable. Where spurious relationships cannot be ruled out, hypotheses would have to be appropriately developed.

Selection bias

Selection bias refers to the problem that, at pre-test, differences between groups exist that may interact with the independent variable and thus be 'responsible' for the observed outcome. Researchers and participants bring to the experiment a myriad of characteristics, some learned and others inherent. For example, sex, weight, hair, eye, and skin color, personality, mental capabilities, and physical abilities, but also attitudes like motivation or willingness to participate.

During the selection step of the research study, if an unequal number of test subjects have similar subject-related variables there is a threat to the internal validity. If subjects in two groups to be compared are not alike with regard to the independent variable, but similar in one or more of the subject-related variables, it may jeopardize the internal validity.

Self-selection to participate in this research can have a negative effect on the interpretive power of the dependent variable, this is especially known for online surveys where individuals of specific demographics opt into the test at higher rates than other demographics.

History

Events outside of the study/experiment or between repeated measures of the dependent variable may affect participants' responses to experimental experiences. Often, these are large scale events (natural disaster, political change, etc.) that affect participants' attitudes and behaviors such that it becomes impossible to determine whether any change on the dependent measures is due to the independent variable, or the historical event.

Maturation

Subjects may change during the course of the experiment or even between measurements. Both permanent changes, such as physical growth and temporary ones like fatigue, provide "natural" alternative explanations; thus, they may change the way a subject would react to the independent variable. So, upon completion of the study, the researcher may not be able to determine if the cause of the discrepancy is due to time or the independent variable.

Repeated testing

Repeatedly measuring the participants may lead to bias. Participants may remember the answers or may be conditioned to know that they are being tested. Repeatedly taking (the same or similar) tests usually leads to score gains.

Instrument change

The instrument used during the testing process can change the experiment, an aspect that we will managed via device quality control to the largest extent possible. This also refers to observers being more concentrated or primed, or having unconsciously changed the criteria they use to make judgments. This can also be an issue with self-report measures such as facility perceptions given at different times. In this case the impact may be mitigated through the use of retrospective pretesting. If any instrumentation changes occur, the internal validity of the main conclusion is affected.

Differential attrition

This error occurs if inferences are made on the basis of only those participants that have participated from the start to the end. However, participants may have dropped out of the study before completion, and maybe even due to the study or experiment itself. If this attrition is systematically related to any feature of the study, the administration of the independent variable, the instrumentation, or if dropping out leads to relevant bias between groups, a whole class of alternative explanations may be possible that account for the observed differences.

Selection-maturation interaction

This occurs when the subject-related variables (color of hair, skin color, etc.) and the time-related variables (age, physical size, etc.), interact. If a discrepancy between the two groups occurs between the testing, the discrepancy may be due to the age differences in the age categories.

Experimenter bias

Experimenter bias occurs when the individuals who are conducting an experiment inadvertently affect the outcome by non-consciously behaving in different ways to members of control and experimental groups. It is possible to eliminate the possibility of experimenter bias through the use of double blind study designs, in which the experimenter is not aware of the condition to which a participant belongs.

F. Data Analysis

At this point we intend to only use descriptive statistics as all aspects of this research are exploratory. Upon further data analytics we will consult with the biostatistician when we explore more definitive statistical assessments.

Funding support
This project is supported by the Ohio Third Frontier Wright-Center for Innovation in Biomedical Imaging project TECH 09-028 and the Wright Center of Innovation development fund.

V. Bibliography

A longitudinal study investigating cervical changes during labor using a wireless ultrasound device. Kim J, Kim S, Jeon S, Jung S. J Matern Fetal Neonatal Med. 2017 Jun 21:1-5. doi: 10.1080/14767058.2017.1329292. [Epub ahead of print] PMID: 28627262

A Multimedia Tutorial to Train Ultrasonography of the Thyroid for Medical Students. Ritter J, Wolfram M, Schuler S, Guntinas-Lichius O. Laryngorhinootologie. 2017 May 9. doi: 10.1055/s-0043-104863. [Epub ahead of print] German. PMID: 28486740

A System-on-Chip Solution for Point-of-Care Ultrasound Imaging Systems: Architecture and ASIC Implementation. Kang J, Yoon C, Lee J, Kye SB, Lee Y, Chang JH, Kim GD, Yoo Y, Song TK. IEEE Trans Biomed Circuits Syst. 2016 Apr;10(2):412-23. doi: 10.1109/TBCAS.2015.2431272. PMID: 26954842

Carotid arterial blood pressure waveform monitoring using a portable ultrasound system. Joohyun Seo, Pietrangelo SJ, Hae-Seung Lee, Sodini CG. Conf Proc IEEE Eng Med Biol Soc. 2015 Aug;2015:5692-5. doi: 10.1109/EMBC.2015.7319684. PMID: 26737584

Comparison of a pocket-size ultrasound device with a premium ultrasound machine: diagnostic value and time required in bedside ultrasound examination. Stock KF, Klein B, Steubl D, Lersch

C, Heemann U, Wagenpfeil S, Eyer F, Clevert DA. Abdom Imaging. 2015 Oct;40(7):2861-6. doi: 10.1007/s00261-015-0406-z. PMID: 25805559

Effects of Ultrasound Implementation on Physical Examination Learning and Teaching During the First Year of Medical Education. Dinh, V. A., Frederick, J., Bartos, R., Shankel, T. M. and Werner, L. Journal of Ultrasound in Medicine (2015), 34: 43–50. doi:10.7863/ultra.34.1.43

Miniaturizing Ultrasonic System for Portable Health Care and Fitness. Tang HY, Seo D, Singhal U, Li X, Maharbiz MM, Alon E, Boser BE. IEEE Trans Biomed Circuits Syst. 2015 Dec;9(6):767-76. doi: 10.1109/TBCAS.2015.2508439. Epub 2016 Jan 18. PMID: 26780818

Pocket-sized point-of-care cardiac ultrasound devices : Role in the emergency department. Colclough A, Nihoyannopoulos P.Herz. 2017 May;42(3):255-261. doi: 10.1007/s00059-016-4531-4. PMID: 28341982

Point-of-Care Ultrasound in a Department of Pediatric and Adolescent Surgery. Avinadav E, Almog A, Kravarusic D, Seguier E, Samuk I, Nika A, Freud E. Isr Med Assoc J. 2016 Nov;18(11):677-679. PMID: 28466618

Training Midwives to Perform Basic Obstetric Point-of-Care Ultrasound in Rural Areas Using a Tablet Platform and Mobile Phone Transmission Technology-A WFUMB COE Project. Vinayak S, Sande J, Nisenbaum H, Nolsøe CP. Ultrasound Med Biol. 2017 Jul 14. pii: S0301-5629(17)30247-8. doi: 10.1016/j.ultrasmedbio.2017.05.024. [Epub ahead of print] PMID: 28716434

Training Program for Cardiology Residents to Perform Focused Cardiac Ultrasound Examination with Portable Device. Siqueira VN, Mancuso FJ, Campos O, De Paola AA, Carvalho AC, Moises VA. Echocardiography. 2015 Oct;32(10):1455-62. doi: 10.1111/echo.12887. Epub 2015 Jan 21. PMID: 25604804