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Part I: Ultrasound Education in Cusco, Peru

Background

The practice of medicine in low- and middle-income countries (LMIC) is hindered by a variety of problems, including lack of access to imaging modalities to help with diagnosis and treatment[1]. However, ultrasound imaging may be uniquely positioned to make a major impact on this problem. Ultrasound machines have increasingly become smaller and more portable and are uniquely affordable in comparison to other modalities, while ultrasound imaging itself is not harmful to patients and provides point-of-care data that can be used for clinical decision-making[2]. Several studies have addressed the role that ultrasound can play in changing the diagnosis and management of patients in LMIC[3-5], with results demonstrating that management changed in a large proportion of cases and was generally useful for treatment. In many of the studies conducted, ultrasound was shown to be most helpful in the diagnosis and treatment of obstetric and gynecological conditions, however there is evidence that it can be useful in a wide variety of conditions, including but not limited to trauma, pulmonary and cardiac disease[1,6]. Additionally it has been shown that in resource-limited settings, individuals who are not experienced in the use of ultrasound can be trained to diagnose a variety of conditions with ultrasound at a high degree of sensitivity[6,7].

According to the WHO's healthcare systems rankings, Peru was ranked 129th in the world out of 191 countries[8], and per the World Bank in 2014 Peru was ranked 96th in health care spending per capita[9]. Although it is possible that the country's healthcare system has improved in that time, healthcare clearly remains underfunded. Cusco is one of the main cities in the Andean region of Peru; Cusco Regional Hospital (CRH) is a 312-bed hospital that serves a population of 1.2 million people and has faculty in all major specialties. In June of 2016, a group of UCSD physicians, as well as myself, traveled to Cusco to provide a 2-week ultrasound curriculum to residents at CRH. The goal of the trip was to provide a condensed educational experience to allow internal medicine and emergency medicine residents at CRH to effectively use ultrasound machines that were being donated by UCSD, as well as to foster a continuing relationship with CRH. The initial goals and hypotheses this research project was designed to look at are elucidated below.

Project Goals:
Goal 1. To characterize the utilization of ultrasound in the urgent and emergency department setting at CRH before and after an educational ultrasound curriculum is implemented. Rates of utilization, body part examined, gender of patient, age of patient and chief complaint will be captured before and after the educational intervention.
--*Hypothesis 1.* There will be an overall increase in number of ultrasound exams performed after the educational curriculum is implemented.

Goal 2. To assess (A) the perceived comfort level of providers in the ED at CRH with using ultrasound imaging and (B) the perceived utility of ultrasound imaging in this setting, before and

after an educational ultrasound curriculum is implemented.
--*Hypothesis 2a.* There will be an increase in self-reported comfort level of providers with use of ultrasound in this setting after the educational curriculum is implemented.
--*Hypothesis 2b.* There will be an increase in self-reported perception of utility of ultrasound in this setting after the educational curriculum is implemented.

Goal 3. To characterize the impact of ultrasound use on treatment decision-making, as assessed by physician self-report.
--*Hypothesis 3*. The majority of patients for which ultrasound influences management will have obstetric or gynecologic conditions, followed by cardiovascular conditions.

Planned Methods

Participant Recruitment:

The study was designed to examine the utilization of ultrasound at CRH before and after the implementation of an intensive two-week ultrasound training pilot program, taught by UCSD Emergency Medicine physicians who are trained and credentialed in point-of-care ultrasound. Instructors include the Emergency Ultrasound Fellowship director and the Emergency Ultrasound Fellow. All the local providers being studied are employed by CRH. All providers working during the time that the UCSD physicians will be at CRH will be invited to participate. Participation involves completion of pre- and post- surveys. The providers will be asked if they are willing to participate in these surveys during morning conference at the outset of the two-week study period. Those providers who agree will be given a description of the purpose of the study, and baseline surveys to complete (see attached).

Aim 1.

Throughout the duration of the study period, daily record of number of ultrasound exams performed, body part of patient, age of patient, gender of patient and chief complaint will be kept. This information will be recorded in a tallied fashion i.e. the gender, age and chief complaint of one patient will not be linked.

Aim 2.

After participant enrollment, each provider will be asked to complete a pre-ultrasound course survey assessing each providers' perceptions of the utility of ultrasound, how likely they think they are to use ultrasound for various common chief complaints, how likely they think ultrasound will impact treatment decision-making, and their self-assessment of ultrasound skills. This survey will be repeated at the end of the study period. [attached]

Aim 3.

During the day, Peruvian providers will perform examinations on patients as they would normally, and determine if any of these patients require ultrasound imaging as part of their routine, standard-of-care management. If ultrasound is indicated, at each individual provider's discretion, then the provider will fill out 'Pre-Ultrasound Survey' [attached]. Following ultrasound, the provider will complete 'Post-Ultrasound Survey' [attached].

Analysis

Aim 1. Chi-square tests will be used to compare pre and post training course distributions of categorical characteristics of interest (% of patients undergoing ultrasound, proportion by age group, gender, body part examined).

Aims 2 and 3. These surveys utilize a traditional Likert-type scale and will be analyzed using non-parametric statistical tests. Sign and Mann-Whitney U tests will be used to determine if there is a significant difference between pre- and post-ultrasound subjective beliefs of the providers who have performed the ultrasounds.

Evaluation

The success of this project will be evaluated on the amount of data that is collected during the June trip to Peru, which will also be the end point for data collection in the study. Data analysis will occur after this point, and be completed December 2016. The project will be deemed successful if 20 providers in Peru are enrolled in the study, and data is collected from the ultrasounds they perform during the two-week study period. The goals outlined above will accomplished through the use of the surveys and data analysis as discussed in the methods section.

Evaluation Of Project

By the criteria outlined above, the research project was not successful. None of the sets of surveys were completed, leading to a complete lack of data generation. The lack of data generation was secondary to incomplete communication between ourselves—at UCSD—and the local providers at CRH. Our expectation had been that we would be supervising the residents as they performed ultrasounds on both previously admitted patients and new admits. However, upon arrival we found that the set-up envisioned by the local providers was such that they expected us to perform ultrasounds on outpatients, who had no previous diagnosis and no inpatient treatment.

Additionally, the lectures were not provided at a morning conference as expected, but rather at a much wider event which was a national conference which many providers were invited to; this meant the majority of people attending the educational lectures were not local providers at CRH, but rather a wide variety of doctors from throughout Peru. Additionally, the week of our visit fell during Cusco's local harvest festival, and a large number of the residents who otherwise would have been part of the educational program, were absent throughout our time there.

Reflection on time in Peru

Although I was unable to complete the research project that I had intended while in Cusco, the experience still held a tremendous amount of value. I still intend to pursue a career that has a heavy component of global health, and although this project was not successful from a research point-of-view, it taught me an enormous amount about what is necessary to do effective work in LMIC and resource-poor settings. The most important lesson is that to make any true impact in these environments one has to have continuity and a true relationship with the local hospital and providers.

The largest component to my not being able to perform the intended research project was lack of familiarity with the setting, and lack of communication with the local providers. Although a member of our team was in communication with the chief of Internal Medicine and Emergency Medicine at CRH, this was a clear barrier toward designing and implementing a research project.

Not being in the same location, and truly being able to visualize what each party's expectations are makes designing any sort of research project essentially impossible. Additionally—and not surprisingly—making a large sustainable impact on care in these locations also requires continuity and communication.

For the remainder of my career in global health, it will always be important for me to remember this occurrence, and to plan accordingly. Had one of the members of our team previously gone down to Cusco to visit the location and understood the setting and circumstances, it would have been much more practical to conduct a research study and understand the specific education needs of the local providers. In fact, if I look at this first trip as an initial visit, from which future projects can be planned and a continued partnership sustained, then this trip was very successful.

The connections that were formed between the UCSD Emergency Medicine department and the faculty at CRH show promise of having a lasting impact. One of the residents at CRH is already in discussion with a plan to visit UCSD and more extensively learn ultrasound skills from the UCSD emergency medicine faculty. Additionally, now that an avenue has been opened for UCSD residents to go to CRH, these international experiences can continue for UCSD residents in the future. Furthermore, now that two ultrasound machines have been donated to CRH, our initial proposal for studies on the use of ultrasound in Cusco will be more achievable.

On a personal level, this experience was tremendously important to understanding my future career. As I noted above, I continue to have interest in a career in global health, and have begun to understand how impossible it is to truly make a lasting impact, or even study a location, without integration in to the community. At the outset of this project I was optimistic that I would be able to complete the research project proposed above: it was survey-based, and seemed very manageable given the time constraints. However, it has become clear to me that it is essentially impossible to conduct a research study of any scope—not to mention implementing any lasting change—without a prior visit to the community, and true engagement of the local providers. As my career goes forward I intend to keep this lesson at the forefront of my mind as I try to continue with international work and intend to not start any research projects until either I, or someone directly supervising me, has physically been to the place I am planning to conduct this research.

Aside from research, being a member of the team that traveled to Peru was hugely useful to my future as a physician. I was able to gain valuable experience performing ultrasound studies, a skill that is a necessity for an Emergency Medicine physician. Additionally, as I attended, and studied, all of the lectures our team gave at CRH, I was able to receive the fully condensed ultrasound didactic seminar. Perhaps most importantly, I was unexpectedly force to act as one of the two main translators for the team, and actually translated many of the lectures that Dr. Campbell and Dr. Xu (the attending and ultrasound fellow on our trip) gave. This was a new experience for me, and one that both improved, and tested the limits of my medical Spanish.

Along with translating the lectures, I frequently served as the translator between the local physicians, or patients, and our team, which gave me an intimate reminder of how important language is to the practice of medicine. In the US, it is very easy to develop an attitude of blaming patients, and being very cursory with translations if a patient does not speak English. While it is easy

to intellectually realize this is not an appropriate attitude to have towards patients, time constraints often lead to this behavior occurring regularly. However, when placed in an environment in which almost none of the patients—and very few of the providers—speak English, it forces me to step back and realize how anglo-centric my worldview often is. In some way I used to think of the language barrier as one erected by the patient, or maybe nebulously to "circumstances;" but I now accept that responsibility upon myself, and realize that I am equally as culpable in erecting a language barrier by not speaking the patient's primary language. Every patient deserves an equal amount of explanation and care, which is not equivalent to an equal amount of time and energy, and my time in Peru was very important reminding me of this fact.

Part II: Increasing Ultrasound Gel Sterility for Low-Resource Environments

Background

As noted above, ultrasound is a tool well suited for use in LMIC. As such, an effort should be made to expand the capabilities in LMIC to include all applications for which ultrasound is used in the United States. Included with the diagnostic uses noted above, ultrasound is a very useful tool for many procedures, including the placement of central venous access[10,11], paracentesis[12], and thoracentesis[13]. However, it has been noted that apart from its usefulness in health care, ultrasound can be the source of spread of nosocomial infections[14-15]. In an effort to avoid nosocomial infections during sterile procedures, practices adopted in the Unites States include the use of sterile gel and sterile probe covers. In resource limited settings often times sterile gel and probe covers are difficult to procure due to cost or availability (or both); more common disinfectants found in resource-limited settings are simple alcohols (ethyl or isopropyl), and paper towels—which are used to wipe off probes. In both resource-rich and resource-poor settings, infections can be introduced during ultrasound-guided procedures[16], and as such measures have to be taken to avoid these complications. Infection rates can be mitigated by a variety of sterilization procedures, including the use of alcohol-soaked towelettes, or even paper towels to clean ultrasound probes after usage[17,18]. It has also been suggested that the use of alcohol-based hand sanitizer may be an effective means of avoiding transmission by non-sterile ultrasound gel[19].

At UCSD common practice is to clean probes after use with disinfecting wipes; for sterile procedures involving ultrasound probes this cleaning is accompanied with the use of individual sterile packets and a sterile probe cover; however these are not a practical measures in LMIC. During our time at CRH it was noted that there was no access to individual sterile gel packets, nor sterile probe covers. While hand-sanitizer is a viable option for use in this situation, access appeared to also be somewhat limited at CRH, and potentially could be difficult to obtain in other LMIC hospitals. Furthermore, subjectively the ultrasound experts from UCSD found hand-sanitizer to be a difficult medium to perform procedures with. Isopropyl alcohol is known to be an effective disinfectant[20], and mixing non-sterile ultrasound gel with isopropyl alcohol may be an effective means of creating a sterile ultrasound gel in resource-poor settings.

This study is a pilot aimed at characterizing whether adding isopropyl alcohol to ultrasound gel is a viable alternative to the use of sterile ultrasound gel packets, in the prevention of infection during ultrasound-guided procedures. Our research question was if there an increased risk of infection using non-sterile gel or non-sterile gel combined with isopropyl alcohol in comparison to use of sterile gel. We hypothesize that the addition of isopropyl alcohol will convert non-sterile ultrasound gel to a level of sterility comparable to sterile, single-use ultrasound gel packets.

Methods

The study was performed in the UC San Diego Simulation Center, using ultrasound devices, linear probes, and ultrasound gel that are in communal use for educational purposes, and are not used in any clinical setting. The authors acted as the study participants. Samples were taken from individual skin sites on participant arms and legs. Participant skin sites were cleaned using alcohol swabs. Probes were cleaned by wiping with paper towels followed by alcohol swabs. Probes were then dipped in ultrasound gel that had been placed in a sterile field. The probe with gel was then place don the previously sterilized skin sight for 5 seconds and then removed. The skin site was then swabbed using a standard cotton-tipped swab, which was then swabbed onto a culture plate (BD BBL Trypticase Soy Agar with Sheep Blood). This process was repeated for each subsequent sample taken.

The ultrasound gel that was used was divided in to 3 groups: sterile ultrasound gel, non-sterile ultrasound gel, and 50% non-sterile ultrasound gel mixed with 70% isopropyl alcohol (mixed). Samples were taken on the same day for sterile and mixed gel groups, isolated to separate sides of the body. Samples for the non-sterile group were taken on a separate day using the same equipment. Control samples from the gels were swabbed without any contact with skin.

Culture plates were incubated for 5 days at 37ºC, at which point they were removed and plates were assessed as to whether or not any bacterial growth had occurred. Standard gram-staining procedures were used to identify the genus of the organisms that grew on the plates.

A right-tailed chi-squared test was used to analyze the difference between the groups.

Results

At 5 days time 8 out of 80 plates from the non-sterile gel group had any growth. The mixture group had growth on 19 out of 96 plates, and the sterile gel group had growth on 19 of 96 plates. 0 of 6 of the non-sterile gel and mixture control plates had growth; 1 of 4 of the sterile gel control plates had growth (table 1). The overall significance of the difference in growth seen had a p-value of 0.07, as did the difference between non-sterile gel and both the mixed and sterile groups. The difference of growth seen between sterile and mixed had a p-value of 0.98. Results of gram-staining are pending.

Condition	**Control plate growth**	**# Plates with growth/Total plates**	**Chi-Squared (compared to non-sterile)**	**Chi-Squared (compared to sterile)**
Non-sterile	0/6	8/80	N/A	P = 0.07
Mixture	0/6	19/96	P = 0.07	P = 0.98
Sterile	1/4	19/96	P = 0.07	N/A

Table 1

Discussion

This pilot study indicated that there was no significant difference in bacterial contamination between ultrasound gels of any type. This result is consistent with results observed that indicate that non-sterile gel is at least equivalent to the use of sterile gel in some instances[16,17]. Additionally, other studies have shown that ultrasound probes themselves can lead to nosocomial infections[18]. Preliminary gram stains of the cultured bacteria indicate that the contaminants are mostly skin flora and (strep and staph species), although the final gram staining is not completed on this project yet.

Importantly, it was impossible to reject the null hypothesis that all three conditions were equivalent. The identical growth rate from the sterile ultrasound gel and the 50% mixture of non-sterile ultrasound gel and 70% isopropyl alcohol indicates that there was no real difference between those two conditions, and in fact they may be equivalent for use in sterile procedures. There are, however, several caveats to this conclusion. The first is that the control plates for the non-sterile gel failed to have any growth at all, indicating there was likely no bacterial contamination within the gel. Therefore, there were no bacteria to be sterilized by the isopropyl alcohol that was added to the mixture. It is a known problem that ultrasound gels can be come contaminated, and a single contaminated ultrasound gel can represent a nosocomial hazard[21,22]. Given these data, it is likely that bacterial contamination in our study was from skin flora. We designed this study so as to replicate procedural conditions: by swabbing the skin after the probe was placed upon it, we attempted to simulate the action of placing ultrasound guided intravenous-access, or an ultrasound-guided injection. This procedure adds the skin and probe as factors that may be carrying contaminants, and does not isolate the gel as a source.

Given the data from this study, as well as the literature from other studies, it is difficult to point to significant evidence that shows a substantial difference on a large scale between the use of sterile ultrasound gel and non-sterile gel. However, this does not mean that the use of individual sterile packets does not make logical sense in resource-rich settings where it is possible. This practice precludes the issue of contaminated gel sources that was outlined earlier. Unfortunately, this study does not provide evidence that isopropyl alcohol is an effective means to limit nosocomial infections, however it does provide evidence that ultrasound gel mixed with isopropyl alcohol does not significantly increase a rate of bacterial contamination compared with sterile ultrasound gel.

Future Work

To complete this research project there are several avenues for future study that can be done. The first is to complete the gram staining of the colonies that has already been started for this project, to identify what genus of microorganism is causing bacterial contamination. This will help identify whether the growth is mainly from skin flora, or from other organisms found within the hospital environment that can lead to infection.

Additionally, a further study that would illuminate the true efficacy of isopropyl alcohol would be to collect ultrasound gel from within the hospital, and culture samples of the non-sterile as well as samples mixed with isopropyl alcohol, without having these samples interact with a study subject or with ultrasound probes. This would be particularly important for application to LMIC, as there is scarce or no access to sterile ultrasound gel packets, and the ability to create sterile gel from previously contaminated gel would be very valuable.

If it is shown that isopropyl alcohol is an effective sterilization method, then examining image quality when the mixed gel is used as a medium would also be important, as image quality issues are one of the main complaints of the use of hand sanitizers as an ultrasound imaging tool. A

blinded study with UCSD ultrasound practitioners would be easy and feasible to accomplish to examine this. An undergraduate (Rachel To) and an Emergency Medicine resident (Heather Boynton) will continue the work with Dr. Campbell on this project, and are aiming to complete these extra steps within the near future.

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