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ORIGINAL RESEARCH

The Practice of Emergency Medicine

Can tablet video-based telehealth assessment of the abdomen safely determine the need for abdominal imaging? A pilot study

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Abstract

Objective: There is limited evidence on the reliability of video-based physical examinations. We aimed to evaluate the safety of a remote physician-directed abdominal examination using tablet-based video.

Methods: This was a prospective observational pilot study of patients >19 years old presenting with abdominal pain to an academic emergency department July 9, 2021–December 21, 2021. In addition to usual care, patients had a tablet video-based telehealth history and examination by an emergency physician who was otherwise not involved in the visit. Both telehealth and in-person clinicians were asked about the patient's need for abdominal imaging (yes/no). Thirty-day chart review searched for subsequent ED visits, hospitalizations, and procedures. Our primary outcome was agreement between telehealth and in-person clinicians on imaging need. Our secondary outcome was potentially missed imaging by the telehealth physicians leading to morbidity or mortality. We used descriptive and bivariate analyses to examine characteristics associated with disagreement on imaging needs.

Results: Fifty-six patients were enrolled; the median age was 43 years (interquartile range: 27–59), 31 (55%) were female. The telehealth and in-person clinicians agreed on the need for imaging in 42 (75%) of the patients (95% confidence interval [CI]: 62%–86%), with moderate agreement with Cohen's kappa ((k = 0.41, 95% CI: 0.15–0.67). For study patients who had a procedure within 24 hours of ED arrival (n = 3, 5.4%, 95% CI: 1.1%–14.9%) or within 30 days (n = 7, 12.5%, 95% CI: 5.2%–24.1%), neither telehealth physicians nor in-person clinicians missed timely imaging.

Conclusion: In this pilot study, telehealth physicians and in-person clinicians agreed on the need for imaging for the majority of patients with abdominal pain. Importantly,

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telehealth physicians did not miss the identification of imaging needs for patients requiring urgent or emergent surgery.

KEYWORDS
assessment, clinical assessment, clinical care, telehealth, telemedicine

1 | INTRODUCTION

1.1 | Background

Telehealth has grown exponentially during the COVID-19 pandemic, including a 63-fold increase in telehealth use by Medicare beneficiaries between 2019 and 2020.[1] In this context, determining how telehealth can be safely deployed is imperative.[2] A critical clinical decision point for a telehealth clinician is to determine whether a patient requires further evaluation not available remotely (eg, in-person examination, imaging, or laboratory tests). For patients seeking a telehealth evaluation for abdominal pain, the reliability of video-based abdominal pain assessment is key to this decision-making process. However, although the reliability of a video-based examination has been demonstrated in a few specific components of the physical examination (eg, stroke severity assessment),[3] data on the abdominal exam are limited. Furthermore, in general, the reliability of video-based examinations with physical examinations that require any tactile components, such as the palpation of the abdomen, is both less well accepted and is limited in the literature.

1.2 | Importance

Abdominal pain is the most common presenting complaint for emergency department (ED) patients, accounting for 8% of ED visits in 2018.[4] Evaluation of abdominal pain is nuanced and often depends on additional information, and there is a lack of evidence to guide whether a remotely performed abdominal examination can be trusted to adequately triage these patients.[5–7] Thus, as patients increasingly seek urgent evaluations via telehealth, assessing the reliability of a video-based abdominal examination is paramount to inform whether any abdominal pain complaints may be safely evaluated via this modality. We previously found 80% agreement between video-based telehealth and in-person emergency clinicians on the decision to perform imaging for patients presenting to an ED with abdominal pain.[8] However, this was from a small sample in a study using a large telehealth video cart. In this first phase of our study, we used a video cart initially created for telehealth use in acute stroke evaluations.[8] This video cart included a high-resolution camera that could be controlled by the physician, including zooming in and out and panning across the examination room. After the first phase of our study, we wanted to better mimic the context of patients being examined remotely. To do so, in this study we used a tablet that was controlled by the patient.

1.3 | Goals of this investigation

In order to confirm reproducibility, and also in consideration of generalizability to settings in which patients may access telehealth via laptops, tablets, or even smartphones, we conducted a study of remotely performed abdominal examinations by emergency physicians via video-based telehealth using a tablet (iPad, Apple, Cupertino, CA). Our goal was to determine whether the physician performing the telehealth abdominal assessment could safely identify patients requiring imaging within 12 hours from the telehealth assessment.

2 | METHODS

2.1 | Setting and population

This was a prospective, blinded observational pilot study of patients being seen for abdominal pain in an academic, Level 1 trauma center ED in Eastern Massachusetts with approximately 110,000 visits per year. Eligible patients were English speaking, over 19 years old, and with a presenting complaint of "abdominal pain" in an ED visit between July 9, 2021 and December 21, 2021. Patients were excluded if they were triaged to the critical care area of the ED or were known to be pregnant. This was a convenience sample, composed of patients who were screened when both a research coordinator and a study physician were available to enroll patients. This tended to be on weekdays during business hours.

The health care system's institutional review board approved this study with requirement for informed consent. This study was registered with ClinicalTrials.gov (2018P002608). We followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement reporting guidelines for observational studies.[9]

2.2 | Patient evaluation

The telehealth evaluations occurred early during the patient's ED visit. Because we did not want to disrupt the flow of the ED, this sometimes occurred before and sometimes after the initial in-person evaluation. Detailed descriptions of the patient evaluations have been previously reported.[8] Briefly, the in-person examination followed the current standard of practice. In addition to usual (in-person) care, patients had a tablet video-based telehealth history and examination by a board-certified emergency physician who was otherwise not

involved in the visit. During the telehealth physical examination, the telehealth physician observed and verbally directed patients through physical examination maneuvers. A trained research coordinator was in the room with the patient to help with technology issues; however, these individuals were not allowed to assist with the physical examinations. Telehealth physicians did not have access to patient records and were not given advanced instructions or guidance on how to conduct their patient evaluations. All patients were examined by board-eligible or board-certified emergency medicine attendings in person and via telehealth. In-person examinations were often also performed by residents or advanced practice clinicians in addition to the board-certified/board-eligible attending emergency physician. The documented examination in the electronic health record reflected the full in-person clinical team's assessment. The telehealth examination was conducted distinctly from the routine clinical encounter and was not documented in the electronic health record.

During the video evaluation, a trained clinical research coordinator gave the ED patient an iPad with a preloaded single application so the patient and telehealth physician could see and hear each other during the encounter. The software used for the examination was CareTeam Connect (Mass General Brigham Health, Boston, MA), which created a secure link into a Zoom (Zoom Video Communications, San Jose, CA) meeting. The videos were not recorded.

2.3 | Data collection

Immediately after the patient evaluations, an automated survey was completed by the in-person clinicians and telehealth physicians using Research Electronic Data Capture (REDCap; Vanderbilt University, Nashville, TN) (Figure S1). A member of the in-person clinical team used an iPad to complete the survey, which included the question "Do you think this patient requires abdominal imaging in the next 12 hours?" with "yes" or "no" as the response options. Compared to our prior study, the clinicians in this study did not have the option to respond "unsure" to the question of need for imaging. Instead, if the clinician reported that they would image, a follow-up question presented, "How certain are you of this answer?" with "very uncertain," "somewhat uncertain," "neutral," "somewhat certain," and "very certain" as response options. Telehealth physicians received their survey via email and responded to the same questions as the in-person clinicians.

We collected additional patient characteristics during the visit, including age, gender, race, ethnicity, and triage vital signs (heart rate, temperature, respiratory rate, blood pressure, and oxygen saturation). We also collected variables relating to the ED visit, including ED disposition (admission to the ED observation unit or any inpatient service, discharge from the ED), procedures, consultations, imaging, and imaging results. In follow-up, we conducted chart review to evaluate 30-day safety outcomes. We reviewed electronic health records to determine whether imaging was performed up through day 30 after the index ED visit at any site in our 14-hospital system, and, if so, the type of imaging performed and imaging results. We also collected subsequent ED visit diagnoses after the index visit, discharge diagnoses, procedures related to the abdomen, and ED disposition. All data were collected and entered on REDCap.

The Bottom Line

This pilot study examined the reproducibility of a telemedicine encounter using an iPad for patients with abdominal pain seen by emergency physicians. The outcome was agreement with in-person examinations on the need for imaging and the type of imaging recommended. This replicates a prior study using a mobile video camera cart. The interrater reliability was only moderate and the methodology and preliminary results support the need for further research in this practice.

2.4 | Outcome measures

Our primary outcome was the agreement between the telehealth physicians and in-person clinicians on need for imaging. Secondarily, we sought to determine potential missed imaging by the telehealth physicians that would have led to morbidity or mortality within 30 days of the study visit. We reviewed those patients who either were admitted or had abdominal procedures associated with the index ED visit, or if they had subsequent ED visits, abdominal procedures, or admissions. Additionally, we compared the level of certainty of the decision regarding imaging between telehealth physicians and in-person clinicians.

2.5 | Statistical analysis

Our target sample size of 56 patients provided 87% power at a 2-sided 5% significance level to reject a poor rate of agreement of 50% if the observed rate was 70% or higher.[10] The patient population, subsequent clinical care and disposition characteristics, and clinician level of certainty were characterized using descriptive statistics.

We categorized patients by agreement versus disagreement between the telehealth physician and in-person clinicians. We included both the recommendations to image or not to image as part of the agreement. We present both the percentage of agreement, as it is easily interpretable, and Cohen's kappa, given its wide use in the literature. Both measures have limitations, namely that percentage of agreement does not account for the possibility of agreement by chance, and that Cohen's kappa does not have a straightforward interpretation and its magnitude is affected by the marginal proportions (disagreements) and the number of possible classifications.[10]

We examined bivariate relationships between patient characteristics and clinician agreement using logistic regression, with clinician agreement as the independent variable. Among the subset of patients

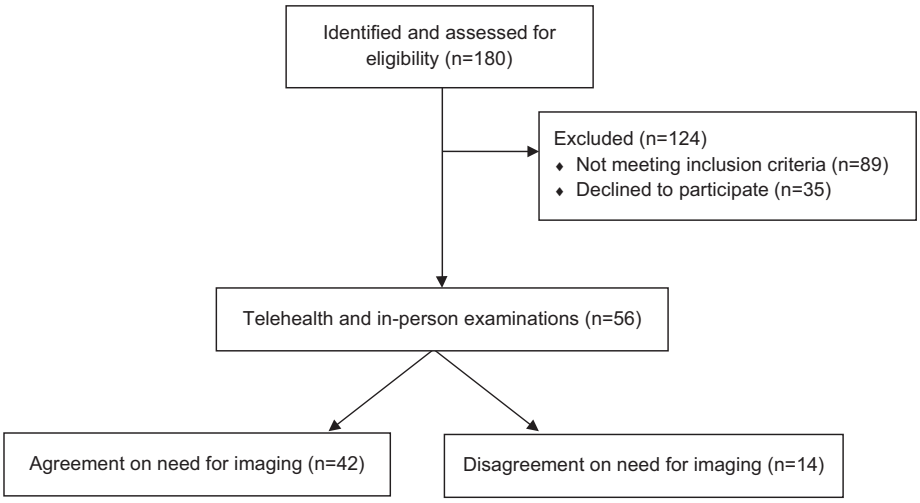

FIGURE 1 Flow diagram of enrollment and agreement.

for whom both clinicians agreed on the need for subsequent imaging, we examined the frequency of agreement on the type of imaging modality requested. Because clinicians could recommend multiple imaging modalities for the same patient, we defined the agreement of imaging modality as having at least 1 recommended modality in common.

We compared the certainty between the telehealth physician and in-person clinicians using Wilcoxon signed rank test and present the distribution-free 95% confidence interval (CI) for the difference in paired certainty level. All analyses were performed using SAS version 9.4 (Cary, NC).

3 | RESULTS

3.1 | Patient characteristics

A total of 56 patients were enrolled (Figure 1), with a median age of 43 years (interquartile range 27–59), 31 (55%) female (Table 1). Seven patients (12%) were admitted from the ED, and 49 (88%) were discharged from the ED. A total of 63 imaging studies were ordered on a total 44 (79%) patients during their ED stay (Table S1). One patient (2%) was evaluated by telehealth before the in-person examination and the remainder had the in-person examination first. Ten patients had a procedure either during the first 24 hours of their index ED visit (n = 3, 5.4%, 95% CI: 1.1%—14.9%) or within 30-days (n = 7, 12.5%, 95% CI: 5.2%—24.1%) (Table S2).

3.2 | Decision on need for imaging

In-person clinicians recommended imaging in the next 12 hours for 38 (68%) patients, and telehealth physicians recommended imaging for 40 (71%) patients. The telehealth physicians and in-person clinicians agreed to image or not image in 42 patients (75%, 95% CI 62%–86%), with both clinicians agreeing in favor of imaging for 32 patients and both agreeing against imaging for 10 patients (Table 2). Cohen's kappa statistic demonstrates moderate agreement (k = 0.41, 95% CI: 0.15–0.67). Of the 32 patients where both clinicians agreed to image, the telehealth physician and in-person clinicians agreed on the imaging modality 81% of the time (Table S3).

We did not identify any patient characteristics associated with increased odds of disagreement between clinicians on the need for imaging, including age, gender, heart rate, and systolic blood pressure (Table 3).

3.3 | Determination of missed imaging opportunities by telehealth physicians

Of the 3 patients who had either an admission or procedures within 24 hours of the index ED stay, the telehealth physician requested imaging on all 3 patients. Upon review of those 7 patients who had procedures in the 30-day follow-up, none of the telehealth physicians missed critical imaging at the index ED visit.

3.4 | Certainty on decision to image

The median level of certainty was high among in-person and telehealth clinicians and was not significantly different between groups (in-person median 5, mean = 4.1; and telehealth median 4, mean = 3.9; median within-patient difference 0, 95% CI: 0–1).

3.5 | Limitations

This study has limitations, including a small sample size from a single center and lack of randomization to telehealth versus in-person examinations. Compared to our prior study, we increased our sample size

TABLE 1 Patient characteristics (n = 56).

Characteristic	
Age (years), median (IQR)	43 (27, 59)
Female gender, n (%)	31 (55)
Race, n (%)	
White, n (%)	43 (77)
Asian	3 (5)
Black or African American	3 (5)
Other	7 (13)
Ethnicity, n (%)	
Hispanic or Latino	4 (7)
Not Hispanic or Latino	49 (88)
Unknown	3 (5)
Vital signs, mean (SD)	
Initial temperature, Fahrenheit	97.7 (0.6)
Initial systolic blood pressure, mmHg	142.6 (22.8)
Initial mean arterial blood pressure, mmHg	100.5 (13.0)
Initial respiratory rate, breaths per minute	17.7 (1.1)
Initial heart rate, beats per minute	81.3 (16.1)
Initial oxygen saturation	98.2 (1.4)
Imaging examinations performed, n (%)	
None	12 (21)
Abdominal x-ray	2 (4)
Abdominal CT	32 (57)
Abdominal/RUQ/renal ultrasound	7 (13)
Abdominal MRI/MRCP	2 (4)
Pelvic ultrasound	7 (13)
Chest x-ray or CT	6 (11)
Point of care ultrasound	6 (11)
ED disposition, n (%)	
Admitted	8 (14)
Discharged	48 (86)
30-day follow-up, n (%)	
ED visits	8 (14)
Inpatient admissions	2 (4)
Procedures	7 (13)

Abbreviations: CT, computed tomography; ED, emergency department; IQR, interquartile range; MRCP, magnetic resonance cholangio pancreatography; MRI, magnetic resonance imaging; RUQ, right upper quadrant..

TABLE 2 Agreement between in-person versus telehealth clinician recommendations (n = 56).

		In-person team	
Telehealth physicians	Does the patient require imaging?	No	Yes
	No	10 (18%)	6 (11%)
	Yes	8 (14%)	32 (57%)

TABLE 3 Factors associated with disagreement between in-person team and telehealth physician on the decision to image in the next 12 hours (n = 56).

Factor	Odds ratio	95% confidence interval
Patient age per 10-year increase (per decade)	1.17	(0.83, 1.64)
Female gender	1.64	(0.47, 5.71)
Initial heart rate >100 or <60	1.16	(0.26, 5.15)
Initial SBP <100 or >180	3.33	(0.42, 26.24)
Initial SpO2 <95%	[a]	[a]

Note: Vital signs included in the model were those taken at triage. Telehealth physicians did not have triage vitals available when making imaging recommendations; however, vital signs were included in the model to examine whether, as a marker of acuity, they were associated with agreement.
Abbreviations: SBP, systolic blood pressure; SpO2, oxygen saturation.
[a]No patients in the study had an SpO2 < 95%.

to reproduce our initial results and to improve the precision of our estimates. Generalizability may be affected by our sample criteria. It is possible that the patients presenting to the ED for abdominal pain may not be generalizable to the general population or to the population who would access video-based telehealth for their abdominal pain. Our sample included only English-speaking patients; thus, it is possible that this may have introduced bias if there are differences between patients who do and do not require interpreter services, or if there are differences in the clinical encounter that occur when interpreter services are part of the evaluation. In addition, there may be variability between clinicians on their fluency in languages other than English. Most of the in-person evaluations happened before the telehealth evaluations, which may have contributed to differences in the information shared by the patient from the first examination to the telehealth physician, particularly if the patient mentioned any subsequent planned tests. We tried to mitigate this by instructing the patient to not provide information to the telehealth physician regarding any studies or plans from the in-person team. It is possible that we did not find other potential misses, for example, abdominal infections that did not result in procedures but did require antibiotics, by only performing a query of the electronic health record. Finally, we did not collect patients' past medical history as part of this study. However, it is likely that patients' histories elicited by the physicians affected their thought processes and imaging decisions in ways that we could not account for in our analysis.

4 | DISCUSSION

In this pilot study, although the agreement was substantial, it was only moderate in that some of the agreement could have occurred by chance alone. Importantly, there were no instances when the telehealth physician's recommendations against imaging would have missed a finding

that would have led to morbidity or mortality. These findings add valuable evidence that telehealth-based abdominal exams may be feasible and safe in the appropriate setting. Together with our prior work,[8] the 2 studies have now demonstrated 75%–80% agreement between in-person and telehealth examiners. Importantly, we found a similar level of agreement on the need for imaging despite using a lower-resolution iPad in this study compared to the prior study's use of high-resolution video from the telestroke cart, which was created specifically for livestreaming physical examinations for high-stakes clinical decision making. Although there was no missed imaging for patients who ended up with surgery or admission, further study is warranted to fully characterize the reliability of the telehealth abdominal examination.

Limited evidence exists on the reliability of the in-person abdominal examination,[11–13] let alone any video-based physical examinations. Abdominal pain was chosen as it is both the most frequent reason for visit to EDs and is likely already being evaluated in virtual care. Before the COVID-19 pandemic, abdominal pain was typically excluded from lists of potential conditions that video-based urgent cares would see and/or allow. It is very likely that during the COVID-19 pandemic patients were seen over video for presenting concerns of abdominal pain. At the time of this writing, video-based emergency medicine programs include gastrointestinal concerns they treat.[14]

Although one could assume that telehealth physicians may recommend imaging more frequently to make up for uncertainty caused by not being in the same room to examine the patient, the telehealth physicians in this study recommended imaging in 40 patients compared to the 38 patients whom the in-person team recommended, which is 3.6% (95% CI: −13.5%–21.1%) and thus not a significant difference. In our prior study, the telehealth physicians recommended against imaging less often than the in-person clinicians.[8] Although we are not reporting a description of the patient who underwent imaging with negative studies, future research could include an assessment of telehealth and in-person physicians' imaging patterns and an assessment of the potential of overimaging.

During the video-based telehealth encounters in this study, the patient was the only person palpating their abdomen under the telehealth physician's guidance. No visitors who came with the ED patients were allowed to help with the video-based physical examination. It is unclear if the use of care partners, that is, family members, roommates, or friends of a patient, would improve the reliability of the abdominal examination. The use of care partners in a video-based abdominal examination raises potential ethical issues with undue discomfort to a patient or care partner in performing an abdominal examination.[15] There are care models that use video-based telehealth examinations with other health care professionals at the patient's bedside, such as community paramedics on site in a patient's home to facilitate a video visit with a clinician.[16] These health care team members could palpate a patient's abdomen and obtain a set of vital signs to improve the reliability of the physical examination. Future studies could determine the reliability of the video-based abdominal examination with other health care team members or care partners present with the patient and gathering data for the health care clinician.

The level of certainty in decisions to image were similar between the in-person clinicians and the telehealth physicians. This is interesting as we thought the telehealth physician, with the lack of palpation of the abdomen and lack of vital signs, would report higher uncertainty. Although a criticism of using video-based telehealth with patients at home is the clinician does not have a set of reliable vital signs, the increased use of remote monitoring equipment or new care models with paramedics in the homes makes it possible for accurate vital signs for such telehealth encounters. It should be noted that based on the results of our study, the availability of any vital signs may not change the decision to image, but that abnormal vital signs would likely cause the telehealth physician to recommend an in-person evaluation that may lead to abdominal imaging. Future similar studies may consider asking the telehealth physician if they think an in-person examination is needed or study how having vital signs would change their recommendation.

There are several areas for future research, such as reproducing these findings in other settings using the same methodology and determining which patient and clinician characteristics lend themselves to a safe telehealth-based examination. Other future studies could determine the reliability of the video-based abdominal examination with other health care team members or care partners present with the patient who gather data for the health care clinician. Post hoc video review of the telehealth abdominal examinations could lend more evidence on the level of agreement between clinicians. Finally, future studies could explore if the order in which the telehealth and in-person examination are performed leads to bias in the results.

In summary, telehealth physicians and in-person clinicians agreed on the need for imaging for most patients included in the pilot study. Notably, in this single-site study of 56 patients, we found that the telehealth physicians did not miss imaging that led to morbidity or mortality. Nevertheless, caution should be used when interpreting this study as this was a small study of stable ED patients. Given the increased use of telehealth, it is critical to determine how telehealth can be safely implemented. Further study should focus on the reproducibility of these findings in a broader and larger group of ED patients, including the use of non-imaging diagnostics in this patient population.

AUTHOR CONTRIBUTIONS

Emily M. Hayden and Kori S. Zachrison study concept and design; Emily M. Hayden, Eleonore Kugener, and Kori S. Zachrison acquisition of the data; Emily M. Hayden, Eleonore Kugener, Blair A. Parry, Kori S. Zachrison, Nora Horick, Michael R. Filbin, Pierre Borczuk, Sayon Dutta, Shan W. Liu, and Benjamin A. White analysis and interpretation of the data; Emily M. Hayden, Eleonore Kugener, Blair A. Parry, and Kori S. Zachrison drafting of the manuscript; Emily M. Hayden, Eleonore Kugener, Blair A. Parry, Kori S. Zachrison, Nora Horick, Michael R. Filbin, Pierre Borczuk, Sayon Dutta, Shan W. Liu, and Benjamin A. White critical revision of the manuscript for important intellectual content; Nora Horick and Kori S. Zachrison statistical expertise; and Emily M. Hayden and Kori S. Zachrison acquisition of funding.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest..

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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