Telemedicine-guided point-of-care ultrasound can be feasible and effective in a life-threatening situation: The case of a field hospital during the COVID-19 pandemic

Tarso Accorsi, Karine De Amicis Lima, Alexandra Brigido, Deborah Belfort, Fabio Habrum, Fernando Scarpanti, Iuri Magalhães, José Filho, Leon Sampaio, Maria Lira, Renata Morbeck, Carlos Pedrotti, Fabio Racy, Eduardo Cordioli

Submitted to: Journal of Medical Internet Research
on: October 06, 2020

Table of Contents

Telemedicine-guided point-of-care ultrasound can be feasible and effective in a life-threatening situation: The case of a field hospital during the COVID-19 pandemic

Tarso Accorsi[1] MD, PhD; Karine De Amicis Lima[1] MSc, PhD; Alexandra Brigido[1] MD; Deborah Belfort[1] MPH; Fabio Habrum[1] MD; Fernando Scarpanti[1] MD; Iuri Magalhães[1] MD; José Filho[1] MD; Leon Sampaio[1] MD; Maria Lira[1] MD; Renata Morbeck[1]; Carlos Pedrotti[1] MD; Fabio Racy[2] MD; Eduardo Cordioli[1] MD, MSc, MBA

[1]Telemedicine Department, Hospital Israelita Albert Einstein Sao Paulo BR
[2]Israeli Institute of Social Responsibility, Hospital Israelita Albert Einstein São Paulo BR

Corresponding Author:
Tarso Accorsi MD, PhD
Telemedicine Department, Hospital Israelita Albert Einstein
Av. Albert Einstein, 627. Bloco B, 2 floor
Secretaria da Unidade de Telemedicina
Sao Paulo
BR

Abstract

Background: Lightweight portable ultrasound is widely available, especially in inaccessible geographical areas. It demonstrates effectiveness and diagnosis improvement even in field conditions but no precise information about protocols, acquisition time, image interpretation, and the relevance in changing medical conduct exists. The COVID-19 pandemic implied many severe cases and the rapid construction of field hospitals with massive general practitioner (GP) recruitment.

Objective: This prospective and descriptive study aimed to evaluate the feasibility of telemedicine guidance using a standardized multi-organ sonographic assessment protocol in untrained GPs during a COVID-19 emergency in a field hospital.

Methods: Eleven COVID-19 in-patients presenting life-threatening complications, attended by local staff who spontaneously requested on-time teleconsultation, were enrolled. All untrained doctors successfully positioned the transducer and obtained key images guided by a remote doctor via telemedicine, with remote interpretation of the findings.

Results: Only four (36%) general practitioners obtained the appropriate key heart image on the left parasternal long axis window, and three (27%) had an image interpreted remotely on-time. The evaluation time ranged from seven to 42 minutes, with a mean of 22.7 + 12.

Conclusions: Telemedicine is effective in guiding GPs to perform portable ultrasound in life-threatening situations, showing effectiveness in conducting decisions.

(JMIR Preprints 06/10/2020:24821)
DOI: https://doi.org/10.2196/preprints.24821

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?
✓ **Please make my preprint PDF available to anyone at any time (recommended).**
Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.
Only make the preprint title and abstract visible.
No, I do not wish to publish my submitted manuscript as a preprint.
2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?
✓ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**
Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain v
Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <a href="http

Original Manuscript

Short Paper

Tarso A. D. Accorsi, MD, PhD1* (tarsoa@einstein.br); Karine De Amicis Lima, MSc, PhD1 (karineamicis@gmail.com); Alexandra R. D. Brigido, MD1 (alexandra_regia@hotmail.com); Deborah de Sa P. Belfort, MD1 (debbelfort@gmail.com); Fabio C. Habrum, MD1 (fabiohabrum@gmail.com); Fernando G. Scarpanti, MD1 (fgscarpanti@gmail.com); Iuri R. Magalhaes, MD1 (iuri_rm@hotmail.com); Jose R. de O. Silva Filho, MD1 (jrosfilho@gmail.com); Leon P. C. Sampaio, MD1 (pablocartaxo@gmail.com); Maria T. S. de S. Lira, MD1 (mtereza.sampaiolira@gmail.com); Renata A. Morbeck, MR1 (renata.albaladejo@einstein.br); Carlos H. S. Pedrotti, MD1 (carlos.pedrotti@einstein.br); Fabio de C. J. Racy, MD2 (fabio.racy@einstein.br); Eduardo Cordioli, MD,1 MSc (eduardo.cordioli@einstein.br)

1. Telemedicine Department, Hospital Israelita Albert Einstein, Sao Paulo, Brazil.
2. Israeli Institute of Social Responsibility, Hospital Israelita Albert Einstein, Sao Paulo, Brazil.

*Correspondence: Phone: +55 11 2151 5420. Fax: +55 11 2151 5420. Email: tarsoa@einstein.br
Address: Av. Albert Einstein, 627. Bloco B, 2 Andar, Secretaria da Unidade de Telemedicina. Sao Paulo – SP. Zip code 05652-900 - Brazil.

Telemedicine-guided point-of-care ultrasound can be feasible and effective in a life-threatening situation: The case of a field hospital during the COVID-19 pandemic

Abstract

Background: Lightweight portable ultrasound is widely available, especially in inaccessible geographical areas. It demonstrates effectiveness and diagnosis improvement even in field conditions but no precise information about protocols, acquisition time, image interpretation, and the relevance in changing medical conduct exists. The COVID-19 pandemic implied many severe cases and the rapid construction of field hospitals with massive general practitioner (GP) recruitment.
Objective: This prospective and descriptive study aimed to evaluate the feasibility of telemedicine guidance using a standardized multi-organ sonographic assessment protocol in untrained GPs during a COVID-19 emergency in a field hospital.
Methods: Eleven COVID-19 in-patients presenting life-threatening complications, attended by local staff who spontaneously requested on-time teleconsultation, were enrolled. All untrained doctors successfully positioned the transducer and obtained key images guided by a remote doctor via telemedicine, with remote interpretation of the findings.
Results: Only four (36%) general practitioners obtained the appropriate key heart image on the left parasternal long axis window, and three (27%) had an image interpreted remotely on-time. The evaluation time ranged from seven to 42 minutes, with a mean of 22.7 + 12.
Conclusions: Telemedicine is effective in guiding GPs to perform portable ultrasound in life-threatening situations, showing effectiveness in conducting decisions.

Keywords: Telemedicine; Point-of-Care Systems; Ultrasonography; Emergencies; Coronavirus Infections.

Introduction

Ultrasound is one of the most cost-effective and versatile medical imaging techniques. Sonographers have utilized it in the pre-hospital setting, emergency departments, operating rooms, intensive care units, and outpatient clinics, as well as for mass casualty and disaster management. Lightweight portable ultrasound is widely available and has demonstrated effectiveness and diagnosis improvement even in field conditions.1

The remote ultrasound is already used in some situations in inaccessible geographic areas.2 Remote prehospital ultrasound is feasible, mainly in trauma settings.3 A meta-analysis of 28 eligible studies of telesonography in emergency medicine confirmed feasibility, high diagnostic accuracy, and clinical and educational utility. However, despite the demonstration of feasibility, there is no precise information about the protocols, acquisition time, image interpretation, and relevance in changing medical conduct.4 Some case-reports showed benefits of tele-ultrasound in a standardized assessment of cardiac function in shock.5

The COVID-19 pandemic implied many critical cases and forced reorganization of the health system, such as the rapid construction of field hospitals with massive general practitioner recruitment.6 In addition to respiratory complications, COVID-19 can have multiple serious systemic manifestations and the need for specialized assessment, including sonography, often unavailable to specialists in field conditions.7 Telemedicine can meet these demands and telesonography can better assess these patients with life-threatening situations.8 However, the remote guidance of untrained doctors for ultrasound assessment of patients with life-threatening situations in field hospitals has not been investigated.

This study aimed to evaluate the feasibility (number of skills correctly performed and running time) of telemedicine guidance using a standardized multi-organ sonographic assessment protocol in untrained general practitioners (GP) during a COVID-19 emergency in a field hospital.

Methods

Population

This was a prospective and descriptive study, with a single telemedicine center (Hospital Israelita Albert Einstein, Sao Paulo – Brazil) reference for the COVID-19 Pandemic Pacaembu Field Hospital, Sao Paulo – Brazil, with a medical team of GPs without previous ultrasound training. Sequentially, COVID-19 in-patients who presented complications and life-threatening situations attended by local staff who spontaneously requested on-time teleconsultation were enrolled. The inclusion period was from the beginning to the end of the field hospital activities (March to June 2020). This hospital aimed to take care of cases presumably of low-to-moderate risk and had 1515 in-patients, 1212 discharges, 289 high-complexity hospital referrals, and only three in-deaths. Inclusion criteria were patients with shock and/or acutely manifesting dyspnea during hospitalization. Teleconsultation was performed after confirmation of perfect audio and image functioning in the patient and GP's presence. There was no exclusion of cases due to connectivity problems. All telemedicine specialists were cardiologists certified in emergency point-of-care ultrasound (POCUS). After the initial evaluation and with a clinical opportunity, the remote physician applied the ultrasound protocol with the local team.

Standardized ultrasound protocol

All patients were evaluated by Philips Lumify lightweight portable ultrasound with a linear and convex transducer attached to a 10-inch tablet. The image was not transmitted to the telemedicine department and was evaluated remotely by the cardiologist through the tablet screen.

The proposed sonographic evaluation aimed to analyze systolic dysfunction of the left ventricle,

pulmonary congestion, systemic congestion, and hypovolemia. For this purpose, four areas were analyzed from top to bottom: internal jugular vein (IJV), heart, lung, and inferior vena cava (IVC). Each area was analyzed sequentially in three steps: the positioning of the transducer, obtaining the key image of the organ with recognition of normal structures, and recognizing alterations. The IJV was the only area analyzed with linear transducer, in the supraclavicular region transversely, and the absence of diameter variation on exhalation was considered a predictor of right ventricular dysfunction and systemic congestion. The cardiac area was analyzed only in the long axis parasternal window, and systolic dysfunction was defined visually and subjectively ("eyeball"). Each lung was scanned in four quadrants (anterosuperior, anteroinferior, lateral-superior, and lateral-inferior). Lung congestion was defined as at least three B-lines in two quadrants bilaterally. IVC analysis was performed in the subxiphoid region and the suggestion of hypovolemia was the collapse of the vein during deep inspiration in non-intubated patients and a variation greater than 50% in intubated patients.
After remote guidance, the ability to position the transducer to recognize the key-image and to dynamically interpret the images was categorized as “yes” or “no”, and the total time to perform all the steps was computed for each patient from the beginning of the telemedicine call until the end of the sonographic evaluation.

Statistics

Statistics were only descriptive. All continuous variables were described as mean and standard deviation and categorical variables as absolute numbers and percentages.

Results

Eleven patients were evaluated. All untrained doctors were able to position the transducer and obtain key images of the IJV, lung, and IVC when guided by a remote doctor via telemedicine, who remotely interpreted all the findings of these organs. However, only four (36%) general practitioners obtained the appropriate key image of the heart on the left parasternal long axis window and three (27%) had an image interpreted remotely on-time. The evaluation time ranged from seven to 42 minutes, with a mean of 22.7 + 12 (Table 1).

Table 1. Categorization and runtime of the standardized telemedicine-guided POCUS

Patient	**Trans. posit.**[a]	**Key-image detection**	
		IJV[b]	Heart
1	Yes	Yes	No
2	Yes	Yes	No
3	Yes	Yes	Yes
4	Yes	Yes	Yes
5	Yes	Yes	No
6	Yes	Yes	No
7	Yes	Yes	No
8	Yes	Yes	Yes
9	Yes	Yes	Yes
10	Yes	Yes	No

[a]Trans. posit., transductor positioning; [b]IJV, internal jugular vein.

Although not the primary objective of the study, which had a technical focus, the effectiveness of POCUS in evaluation was analyzed, because it influenced the pre-test probability with a change in the diagnostic hypothesis in seven (63%) cases.

Discussion

Principal Results

Telemedicine efficiently increases access to health care, particularly evaluation by specialists. Organized teleconsultation might mitigate emergency disease burden.9 Telemedicine interpretation of cardiac POCUS handled by GP and non-physician healthcare provider has already demonstrated cardiovascular diagnosis improvement in patients in low-resource areas.10 Smith et al. showed that there is no difference in telemedicine accuracy among multiple fixed cameras, smartphones, or audio, regarding the feasibility of remote ultrasound guidance and trainee's perspective.11 Evidence shows that telemedicine teaching is as effective as in-person teaching for the acquisition of bedside ultrasound skills.12 Levine et al. showed that tele-intensivists were able to instruct non-physicians to acquire ultrasound images of the right IJV, bilateral lung apices and bases, cardiac subxiphoid view, and bladder without a quality difference in relation to directly-acquired images.13

Despite progressive evidence of the effectiveness of telemedicine guidance for obtaining ultrasound images, still few studies have evaluated the form and timing of guidance, especially in life-threatening situations in untrained professionals. This study evaluated the number of skills correctly performed and running time in a multi-organ POCUS with remote guidance by a certified professional. The main feature was the spontaneous demand for evaluation by a specialist in a life-threatening condition, characterized by the high emotional stress of an in-situ team. It is also noteworthy that the majority of doctors attending the emergency room were untrained generalists. The top-bottom evaluation was opted because it is more didactic and easier to assimilate. Remote guidance achieved 100% effectiveness in choosing and positioning the transducer, as well as IJV and IVC assessment, independent of the pre-test diagnosis and of whether the patient was intubated or not. In these evaluations, the interpretation of the images by telemedicine was relatively simple.

The major difficulty was cardiac evaluation. It was decided not to recommend the evaluation of the apical window, four chambers, and subxiphoid, respectively, due to position and technical difficulties for inexperienced people. In one-third of the patients, it was possible to interpret the long axis parasternal image. This consumed the greatest time in the evaluation. The decision to interrupt the cardiac evaluation was mutual between doctors and implied an analysis of other clinical data that could show ventricular dysfunction, but whose time was not counted. In half of the cases in which it was not possible to evaluate the heart, the POCUS added value with the other multi-organ evaluations. Intubation hindered cardiac evaluation, but not of the other organs.

In addition to the documentation of the feasibility of most of the evaluated steps, the time spent, although quite variable, was satisfactory, with emphasis on the prolonged time in the cardiac evaluation. The subjective perception on the part of the in-situ staff and telemedicine colleagues was that the POCUS-evaluation time did not hinder the care routine and added real value to the evaluation. In this study, the average of the 4-point assessment was 22 minutes, emphasizing that it was a situation with a wide need for contact precautions because it was a COVID-19 infection. No previous studies have measured the time of assessment in a life-threatening situation.14,15

Effectiveness of POCUS in the patient evaluation was not the primary objective of the study but the results reflected its importance, as in seven (63%) cases POCUS analysis influenced the pre-test probability with a change in the diagnostic hypothesis.

The findings highlight the great ease of complementing the in-situ clinical assessment with remotely guided ultrasound, even in extreme situations.

Conclusions

Telemedicine is effective in guiding untrained GPs practitioners to perform POCUS in life-threatening situations, showing also effectiveness in conduct decisions. Telemedicine-guided ultrasound is feasible promptly, without prejudice to the institutional routine, even in situations of extreme contact precaution as in COVID-19 patients. Telemedicine is reinforced as an easily accessible and cost-effective tool for specialist support and a fundamental strategy for restructuring the health system, even after the pandemic.

Acknowledgements

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. The authors thank the Brazilian representatives of Philips Medical Systems for the constant support provided, especially Mrs. Fabiana Garcia and the Israeli Institute of Social Responsibility, Hospital Israelita Albert Einstein, Sao Paulo, Brazil, for the services provided.

Conflicts of Interest

The Authors declare that there is no conflict of interest.

Abbreviations

JMIR: Journal of Medical Internet Research
Trans. Posit.: Transductor Positioning
IJV: Internal Jugular Vein
POCUS: Point-of-care Ultrasound

References

1. Nelson BP, Melnick ER, Li J. Portable ultrasound for remote environments, part I: Feasibility of field deployment. J Emerg Med. 2011;40(2):190–197. doi:10.1016/j.jemermed.2009.09.006
2. Nagueh SF. Remote ultrasound: New opportunities. JACC Cardiovasc Imaging. 2014;7(8):810–811. doi:10.1016/j.jcmg.2014.05.005
3. Eadie L, Mulhern J, Regan L, et al. Remotely supported prehospital ultrasound: A feasibility study of real-time image transmission and expert guidance to aid diagnosis in remote and rural communities. J Telemed Telecare. 2018;24(9):616–622. doi:10.1177/1357633X17731444
4. Marsh-Feiley G, Eadie L, Wilson P. Telesonography in emergency medicine: A systematic review. PLoS One. 2018;13(5). doi:10.1371/journal.pone.0194840
5. Becker C, Fusaro M, Patel D, et al. Tele-ultrasound to guide management of a patient with circulatory shock. Am J Med. 2017;130(5):e205–e206. doi:10.1016/j.amjmed.2016.12.019
6. Cucinotta D, Vanelli M. WHO Declares COVID-19 a Pandemic. Acta Biomed. 2020;91(1):157–160.
7. Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet. 2020;395(10229):1054–1062. doi:10.1016/S0140-6736(20)30566-3
8. Lopes MACQ, Oliveira GMM De, Ribeiro ALP, et al. Guideline of the Brazilian society of cardiology on telemedicine in cardiology – 2019. Arq Bras Cardiol. 2019;113(5):1006–1056. doi:10.5935/abc.20190205

9. Dierckx R, Inglis SC, Clark RA, Prieto-Merino D, Cleland JGF. Telemedicine in heart failure: New insights from the Cochrane meta-analyses. Eur J Heart Fail. 2017;19(3):304–306. doi:10.1002/ejhf.759
10. Otto CM. Heartbeat: Telemedicine for echocardiography screening. Heart. 2019;105(4):261–263. doi:10.1136/heartjnl-2019-314705
11. Smith A, Addison R, Rogers P, et al. Remote mentoring of point-of-care ultrasound skills to inexperienced operators using multiple telemedicine platforms: Is a cell phone good enough? J Ultrasound Med. 2018;37(11):2517–2525. doi:10.1002/jum.14609
12. Brisson AM, Steinmetz P, Oleskevich S, et al.. A comparison of telemedicine teaching to in-person teaching for the acquisition of an ultrasound skill - a pilot project. J Telemed Telecare. 2015;21(4):235–239.doi:10.1177/1357633X15575446
13. Levine AR, McCurdy MT, Zubrow MT, et al. Tele-intensivists can instruct non-physicians to acquire high-quality ultrasound images. J Crit Care. 2015;30(5):871–875. doi:10.1016/j.jcrc.2015.05.030
14. Blehar DJ, Dickman E, Gaspari R. Identification of congestive heart failure via respiratory variation of inferior vena cava diameter. Am J Emerg Med. 2009;27(1):71–75. doi:10.1016/j.ajem.2008.01.002
15. Martindale JL, Wakai A, Collins SP, et al. Diagnosing acute heart failure in the emergency department: A systematic review and meta-analysis. Acad Emerg Med. 2016;23(3):223–242. doi:10.1111/acem.12878