



## King's Research Portal

DOI:

[10.1089/tmj.2016.0245](https://doi.org/10.1089/tmj.2016.0245)

*Document Version*

Peer reviewed version

[Link to publication record in King's Research Portal](#)

*Citation for published version (APA):*

Silva-Martinez, J. P., Sorice Genaro, A., Wen, H. A., Glauber, N., & Russomano, T. (2017). Remotely Guided Breast Sonography for Long-Term Space Missions: A Case Report and Discussion. *TELEMEDICINE JOURNAL AND E-HEALTH*, 23(12), 1016-1022. <https://doi.org/10.1089/tmj.2016.0245>

### **Citing this paper**

Please note that where the full-text provided on King's Research Portal is the Author Accepted Manuscript or Post-Print version this may differ from the final Published version. If citing, it is advised that you check and use the publisher's definitive version for pagination, volume/issue, and date of publication details. And where the final published version is provided on the Research Portal, if citing you are again advised to check the publisher's website for any subsequent corrections.

### **General rights**

Copyright and moral rights for the publications made accessible in the Research Portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognize and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the Research Portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the Research Portal

### **Take down policy**

If you believe that this document breaches copyright please contact [librarypure@kcl.ac.uk](mailto:librarypure@kcl.ac.uk) providing details, and we will remove access to the work immediately and investigate your claim.

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

# Remotely Guided Breast Sonography for Long-Term Space Missions: A Case Report and Discussion

**Running Title:** Remotely Guided Breast Ultrasound

**Jackelynn P. Silva-Martinez<sup>1</sup>, Andreia Sorice Genaro<sup>2</sup>, Hui Annie Wen<sup>3</sup>, Naama Glauber<sup>4</sup>,**

**Thais Russomano<sup>5</sup>**

<sup>1</sup>International Space University, Houston, TX, USA

<sup>2</sup>International Space University, Sao Paulo, Brazil

<sup>3</sup>International Space University, Montreal, Canada

<sup>4</sup>International Space University, Jerusalem, Israel

<sup>5</sup>MicroG Centre-PUCRS, Porto Alegre, Brazil

## ABSTRACT

**Background:** Space radiation can cause different types of cancers in crewmembers, especially during long-term space missions. **Introduction:** To date, a complete bilateral breast ultrasound has not been performed at the ISS. A breast screening imaging technique could be a useful tool for early identification of breast cancer in astronauts. We hypothesized that breast ultrasound performed by a crewmember while being remotely guided by a specialist from the ground could be an essential tool for medical diagnosis in space. This project aimed to test an ultrasound screening protocol for breast tissue using real-time remotely guided telemedicine techniques. **Materials and Methods:** One female volunteer, with no previous medical experience, performed a self-scanned bilateral breast ultrasound exam guided by a remote sonographer. Dynamic ultrasound images were collected using a 25 mm broadband linear array transducer. To simulate fluid shift on the volunteer during microgravity, the bed was tilted -6 degrees. **Results:** Recorded ultrasound images were analyzed by radiologists, comparing the findings with a gold standard. The experiment demonstrated that real-time remotely guided sonography exam is feasible and can yield meaningful clinical results. **Discussion:** This case study showed that remotely guided breast ultrasound can be performed and might become an important tool for diagnosis of breast cancer in space missions. **Conclusion:** The results cannot be generalized based on one subject, and additional research is warranted in this area in addition to its validation on the ISS. This technique, however, has potential for use as part of preventive medicine procedures for long-term space missions at the ISS, and eventually for human settlements on the Moon and Mars.

**Keywords:** Telemedicine, extreme environments, telehealth, remotely guided, sonography, breast ultrasound, space medicine.

## INTRODUCTION

The space environment is inherently dangerous to human beings due to hazardous phenomena, such as the presence of vacuum, extreme temperatures and space cosmic radiation. Since the beginning of the Space Era, one of the most difficult engineering problems that space scientists have faced is how to develop active and passive methods to reduce space radiation impacts, not only on the spacecraft, but also on the human body. In relation to the evaluation of material properties, both NASA and ESA have conducted several flight experiments in which large numbers of space material samples were exposed to the environment of space and subsequently returned to Earth for laboratory analysis. Astronauts have been travelling into space since 1961, from which time a large volume of research has taken place involving human subjects in order to understand the behavior of the human body under extreme and dangerous conditions, such as the exposure to space radiation. The findings of all these researches have defined astronaut workload and exercise protocols, as well as the medical examination routines onboard the International Space Station (ISS)<sup>3,7</sup>. However, all necessary medical protocols have not yet been fully defined, especially those related to deep space missions (i.e., astronauts travelling to the Moon and Mars). Furthermore, the space environment exposes astronauts to hostile factors that can increase their risk for different types of cancer<sup>2</sup>. Similarly, epidemiological studies have indicated that the incidence of female flight attendants suffering from breast cancer is higher than in the general female population<sup>12,13</sup>. Since female astronauts are exposed to a high level of space cosmic radiation, as compared with flight attendant occupational conditions, they may also present a greater risk of developing breast cancer. According to the Guidelines of the American College of Radiology the breast ultrasound screening in women with dense breasts and negative mammograms during clinical examinations yielded an incremental cancer detection rate of 2.8 to 4.6 cancers per 1,000 women<sup>8</sup>.

1  
2  
3 Based on the NASA ISS Ultrasound Imaging Capability Overview for Prospective Users, NASA/TP-2006-  
4 213731<sup>14</sup>, several protocols that include remote guidance for the detection of signs of diseases have been  
5  
6 developed, focusing on different body systems during missions on the ISS<sup>5</sup>. It is worth mentioning that  
7  
8 most of these medical protocols were previously validated during parabolic flights or on the ISS. However,  
9  
10 no breast sonography has yet been performed on the ISS.  
11  
12

13  
14 The main purpose of our project was to develop a protocol that will help in detecting abnormal breast tissue  
15  
16 characteristics using real-time remotely guided sonography. The implementation of breast sonography  
17  
18 protocols is an essential part of the medical evaluation of female astronauts, especially during long-term  
19  
20 missions. The hypothesis is that it is possible to detect abnormal breast tissue characteristics that may lead  
21  
22 to breast cancer by using real-time guidance from a sonographer on the ground in order to provide more  
23  
24 time and treatment options. In the future, the protocols developed for the crewmembers will become a  
25  
26 solid foundation for performing self and aided breast ultrasounds in deep space missions as preventive  
27  
28 medicine procedures. Due to possible communication delays, the crew will need to be more independent  
29  
30 from the ground, and they will have to run the procedure on their own. However, ground can still provide  
31  
32 remote guidance upon receiving the video and photos collected from the ultrasound made by the crew  
33  
34 member. They can analyze and provide feedback not only for the procedure steps but also for the  
35  
36 diagnosis. This is similar to how results from routine medical exams are provided on Earth; a radiologist  
37  
38 initially performs an X-ray and results are subsequently received during a second medical consultation. A  
39  
40 computer app could eventually be developed to serve as a remote guide for crewmembers, where the tool  
41  
42 can provide recommendations based on the imagery it receives. This could also be embedded into the  
43  
44 design of the ultrasound machine. The available technology will dictate the procedures that will be used in  
45  
46 space for clinical evaluation of astronauts. For example, a still under development "state-of-the-art"  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 approach was proposed in which astronauts can use a motorized probe transducer<sup>1</sup>. This technology could  
4 help female astronauts to be more precise when performing self-examination of their breasts.  
5  
6

7  
8 The authors propose a project of three phases: Phase 1: Experiment Design, Phase 2: Ground Tests, and  
9  
10 Phase 3: Development and Validation Tests for Use in Space. This paper presents the work of Phase 1,  
11  
12 which relates to the establishment of the experiment design. In this phase, a protocol has been developed  
13  
14 that can be used to perform breast ultrasound tests. A pilot test was also conducted in which a test subject  
15  
16 was remotely guided by a sonographer. Phase 2 would consist of repeating the test with other volunteers, as  
17  
18 well as performing the test on people who have been diagnosed with abnormal breast tissue characteristics.  
19  
20 This will help evaluate the training methods for subjects with no medical background performing self  
21  
22 breast ultrasound. In Phase 3, the protocol would include conducting a test on the ISS to validate the  
23  
24 proposed protocol under sustained microgravity.  
25  
26  
27  
28  
29  
30

## 31 **MATERIALS AND METHODS**

32  
33  
34 **Subject.** The study protocol was approved in advance by the International Space University Research  
35  
36 Committee, through the Human Performance in Space Department. This experimental study was performed  
37  
38 with one female subject (case study), who provided signed informed consent. The subject was in her late  
39  
40 30s with advanced education, and had neither a medical background, nor prior experience of performing  
41  
42 breast ultrasounds. A breast ultrasound (gold standard medical exam for breast evaluation) was performed  
43  
44 on the subject as part of routine exams (for clinical reasons) a month prior to this test (control exam), with  
45  
46 the results indicating no evidence of nodules or deformations.  
47  
48  
49

50  
51 **Equipment.** The test was performed at the Ohio University Clinic, USA. The equipment used included a  
52  
53 SonoSite M-Turbo ultrasound machine, a transducer with 25 mm broadband linear array probe with a  
54  
55 frequency of 13-6 MHz (same frequency as the transducer used at the ISS), positioning aids, and acoustic  
56  
57  
58  
59  
60

1  
2  
3 gel<sup>10,16</sup>. Images could be viewed and observed in 2D, M-Mode, Color Flow, and Pulsed Wave Doppler  
4  
5 modes. A reference marker was used to guide image acquisition during the procedure<sup>17</sup>. This had to be  
6  
7 understood by the ultrasound operator and interpreter, as the female volunteer had no prior experience of  
8  
9 performing ultrasounds. The subject was in a 6 degree head-down tilt position to simulate some of the fluid  
10  
11 shift effects of microgravity on human physiology.  
12  
13

### 14 15 ***Experiment Design***

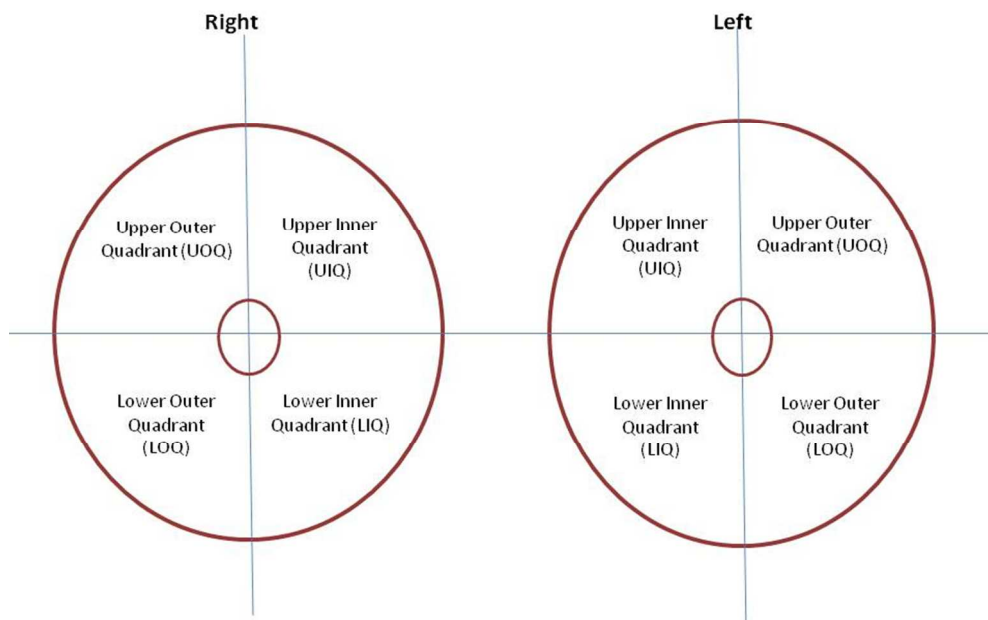
16  
17 The subject was provided with the protocol and was able to ask questions regarding the procedure prior to  
18  
19 the test. The subject also watched a medical video demonstrating a person performing self-ultrasound<sup>15</sup>. It  
20  
21 was shown that both remote guidance and a computer training tool produce a higher quality of ultrasound  
22  
23 images<sup>6,9</sup>. During the procedure, the subject performed the test while guided remotely by the sonographer,  
24  
25 who was in a separate location from the subject. The sonographer, who has previously provided remote  
26  
27 guidance to astronauts on the ISS, was located at NASA's Johnson Space Center and viewed the procedure  
28  
29 via real-time video link, guiding the subject through the sonography steps set out in the protocol, and when  
30  
31 necessary, repeating some steps or explaining them in a different manner to improve the image acquisition.  
32  
33 The subject was located in a room at the Ohio University Clinic, where all the equipment was available. A  
34  
35 second person was also present in the room, serving as the operator of the camera that recorded the  
36  
37 ultrasound images, but having no participation in the remotely guided procedure itself.  
38  
39  
40  
41  
42

### 43 44 ***Procedure – Breast Ultrasound.***

45  
46 The protocol describes the equipment preparation and setup, including the ultrasound machine, transducer  
47  
48 and positioning aids. It also explains how to apply the gel on the transducer and preparation of the breast  
49  
50 for the procedure<sup>4,11,17,18</sup>. The breast was divided into 4 quadrants, as shown in Figure 1, to facilitate the  
51  
52 instructions from the remote sonographer. The protocol included two types of grid scanning patterns with  
53  
54 overlapping passes and a radial scanning pattern, as shown in Figure 2. A flow chart of the protocol  
55  
56  
57  
58  
59  
60

developed is shown Figure 3, and can also be accessed through this link: [https://1drv.ms/w/s!AoeXZB-5sC5HgcY\\_tXAlvhs3MyH4fQ](https://1drv.ms/w/s!AoeXZB-5sC5HgcY_tXAlvhs3MyH4fQ).

A video was used to record the ultrasound images and the subject was asked to state which quadrant was being tested as the procedure was being performed. The remote sonographer observed the process and provided further instructions or feedback, when needed. During the radial scanning pattern, the subject took a picture of the ultrasound image of each quadrant. The video and pictures were reviewed first by a radiologist immediately after the procedure and subsequently by a second radiologist. Both radiologists were blinded to the gold standard/control exam results.



**Figure 1.** Graphic of right and left breasts divided in four quadrants for protocol instructions. UOQ: Upper Outer Quadrant, UIQ: Upper Inner Quadrant, LOQ: Lower Outer Quadrant, LIQ: Lower Inner Quadrant. The quadrant marks repeat for both the right and left breasts, with the difference of going in a counterclockwise position.

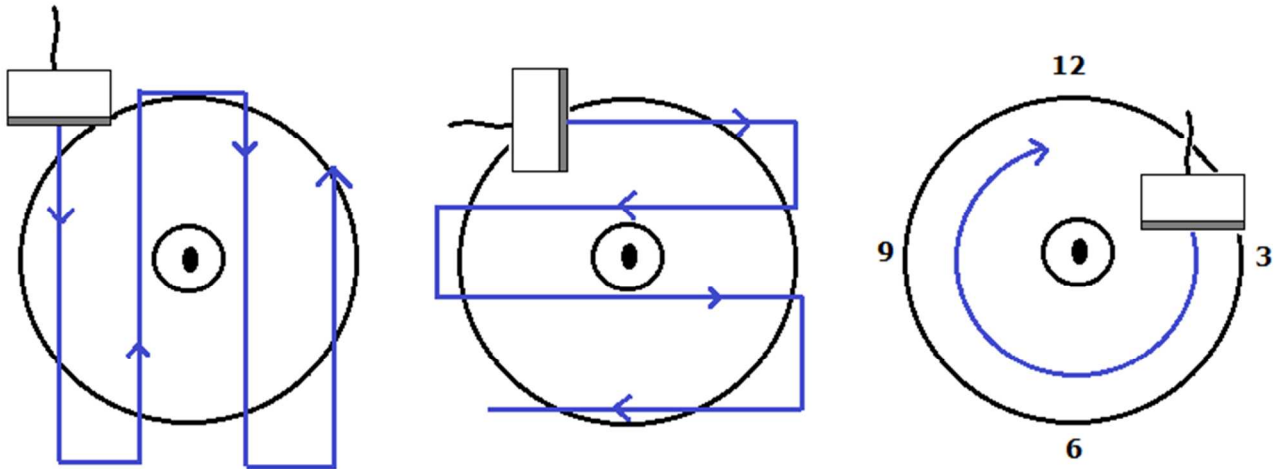


Figure 2. Grid scanning patterns used in protocol for breast ultrasound showing probe placement.

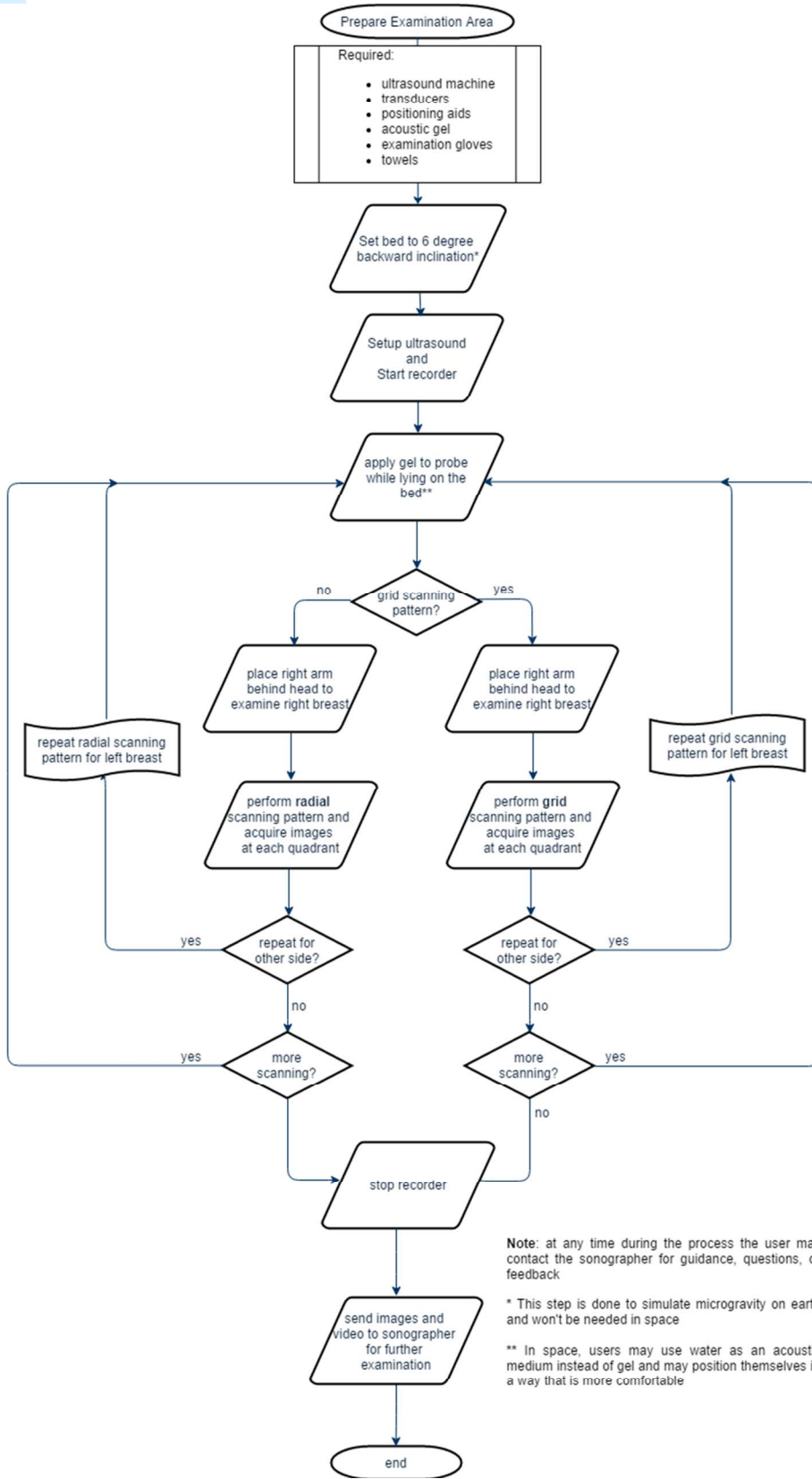


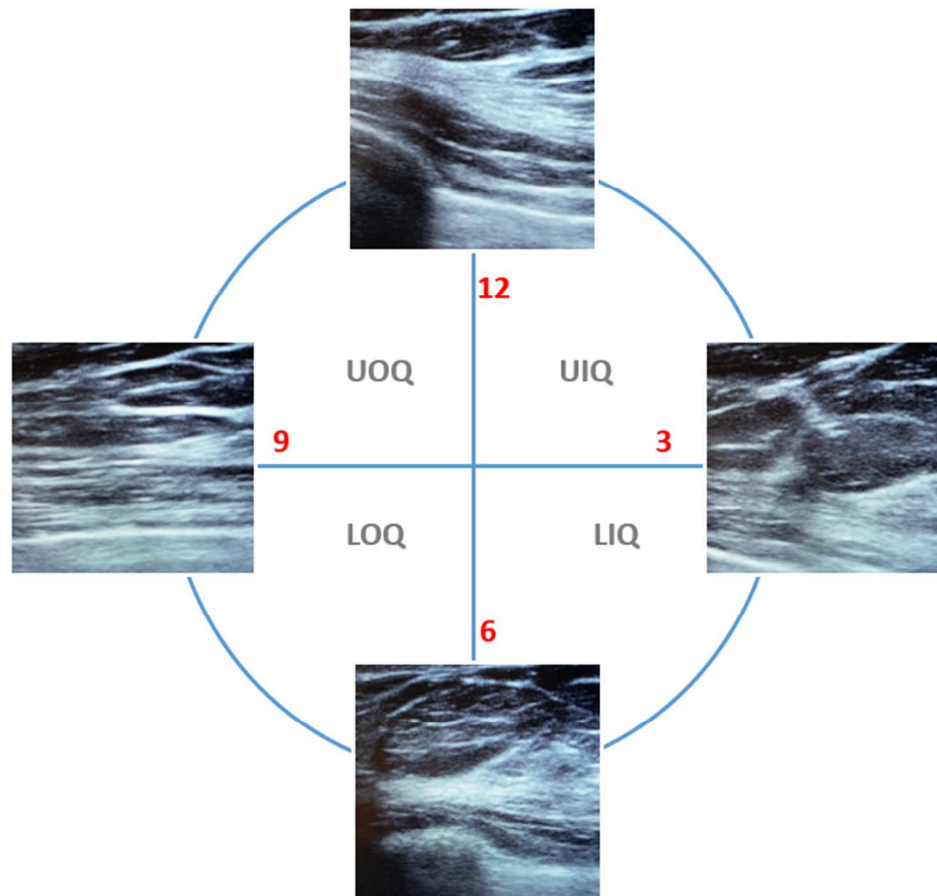
Figure 3. Flow Chart of Protocol developed for ground test of Remotely Guided Breast Sonography

## RESULTS

### *Test Results and Image Analysis*

Upon reviewing the video, radiologists emphasized the importance of using more gel in order to improve the quality of the image obtained. It was also noticed that, initially, the transducer was not fully touching the skin and therefore only flashes of tissue were appearing. This situation improved over the course of the procedure, through guidance given by the remote sonographer. The subject also provided feedback regarding the procedure, noting the arm position to be uncomfortable and that the bed inclination made the procedure more challenging. The amount of pressure required was not clear to the subject, who also noted a difficulty in reading the protocol while performing the test.

Another important observation was the difficulty in determining the exact location of the area being examined from the video alone, as this had no annotations. The only feedback from the video images was the voice of the subject indicating where the ultrasound was being performed. The radiologists reviewed 4 images from each breast quadrant of the radial scanning pattern, as shown in Figure 4, and did not identify any abnormalities. These images were compared with the previous (gold standard/control exam) results from the subject's routine medical exam that indicated no evidence of nodules or deformations. The remotely guided sonography confirmed the same results, exhibiting a true negative study.



**Figure 4.** Representative images of ultrasound taken while scanning at each breast quadrant. The quadrant references to UOQ: Upper Outer Quadrant, UIQ: Upper Inner Quadrant, LOQ: Lower Outer Quadrant, LIQ: Lower Inner Quadrant.

## DISCUSSION

Based on the NASA ISS Ultrasound Imaging Capability Overview for Prospective Users, a complete bilateral breast ultrasound has not yet been performed on the ISS<sup>14</sup>. The ability to identify normal and anomalous breast tissue is of benefit to crew health, and is a responsibility of the space program as any issues could impact mission objectives. Additionally, this tool could aid space medicine in differentiating breast lesions from normal tissue due to the fact that ultrasound increases the chances of positive findings

1  
2  
3 and could be used as a screening tool to spearhead breast health screening on the ISS. It can also expand  
4 ultrasound as a terrestrial tool, particularly in austere environments with limited access to health care  
5 because the patient can perform the exam remotely and the images analyzed by an expert. Breast  
6 ultrasound is especially useful in detection of nodules in dense breast, even as a complement to  
7 mammography screening in these type of patient<sup>8</sup>.  
8  
9

10  
11  
12  
13  
14  
15  
16 Breast cancer affects both genders, but is more prevalent in the female population. This tool will benefit  
17 female space crew and it is an essential component for breast evaluation, especially during long duration  
18 missions.  
19  
20  
21  
22

23  
24 The test environment was not a perfect simulation of microgravity, but highlighted some of the challenges  
25 faced in the performance of remotely guided sonography. Ground-based tests are important in identifying  
26 limitations and improving the protocol for further testing and validation onboard the ISS. However, remote  
27 guidance provided by a sonographer could be adversely affected by communication delays, such as on an  
28 interplanetary trip to Mars, and alternative solutions should be tested. It was also considered that the printed  
29 protocol used in this study could be substituted by a computerized protocol, which could allow for more  
30 interactivity. The video shown to the subject prior to testing provided a general idea of how to perform a  
31 breast ultrasound exam; however, it could be customized for this specific medical procedure to highlight  
32 key aspects of the test. Finally, the results of this case report cannot be generalized. The amount of pre-  
33 flight training required to perform the test in a microgravity environment has to be discussed, tested, and  
34 validated.  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48

49 As discussed in the introduction remotely guided ultrasound can still be done in deep space missions.

50  
51 Since there will be no real time guidance by a sonographer, alternative methods can be considered, such as  
52 the remote guide app or voice guide embedded in the ultrasound machine. The crew will have more  
53 responsibility for the sonography procedure, as there would be limited real-time communication with the  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 ground, which could positively impact on learning skills. They could first attempt the action independently  
4  
5 and then request remote guidance from the ground, if required. This procedure could result in better  
6  
7 learning outcomes as the additional responsibility experienced by the crewmember should lead to increased  
8  
9 confidence levels. For this to work, best practice should include: readily available tools and learning  
10  
11 materials; crew able to use the tools and access any related support; and response time (even if it is just an  
12  
13 estimation) should be known by both the sonographer on the ground and the crewmember.  
14  
15

16  
17 From an ethical viewpoint and human factors considerations, a cabin or partitioned area at the ISS may be  
18  
19 necessary in order to provide privacy for the performance of a breast ultrasound exam. Alternatively,  
20  
21 draping the chest area to shield from the cabin surveillance camera may be necessary. Since gel has to be  
22  
23 applied to the skin to improve the conductivity of ultrasound waves, a type of gel sheet could be used to  
24  
25 deal with privacy concerns, as this could be placed on top of the breasts, decreasing personal exposure. An  
26  
27 ultrasound video with annotation for the remote sonographer would be required to better guide the process.  
28  
29 A second crewmember to assist with operating the ultrasound equipment and possibly with the procedure  
30  
31 itself may be desirable rather than the female crewmember having to perform a self-scan. A few open  
32  
33 questions still remain that would be useful to determine as part of the ISS protocol and training: What  
34  
35 would be the best position for both the patient and the operator, seated versus supine? How much  
36  
37 stabilization would be needed relative to the assisting crewmember? Currently water is used onboard the  
38  
39 ISS for other types of ultrasound, is water a better coupling medium than gel for breast ultrasound? Would  
40  
41 it be necessary to manifest a higher frequency ultrasound probe for better resolution of breast tissue?  
42  
43

44  
45 This initial study is a stepping-stone for detecting abnormal breast tissue characteristics that may possibly  
46  
47 be related to breast cancer in future long-term missions. This does not replace a mammogram and due to  
48  
49 the inherent limitations of a case report it cannot be generalized, yet it provides good focal directed  
50  
51 imaging that could be used for clinical assessment if any type of injury or accident occurs during a mission.  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 Using telemedicine radiology as a breast tissue screening tool on the ISS may demonstrate its clinical  
4  
5 utility in similar austere environments without access to sophisticated clinical screening. This initial study  
6  
7 can serve as a platform for developing treatment protocols. Further testing and validation on the ISS are  
8  
9 needed.  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

## ACKNOWLEDGEMENTS

This work could not have been performed without the support of various people. We would like to thank the International Space University Space Studies Program 2015, for providing the forum to develop our ideas into something more concrete, which can hopefully be useful for future space missions. Thanks to the ISU Human Performance in Space Department Chair, Kris Lehnhardt, and teacher assistant Erika Kupper. Our appreciation goes to experts in the topic who were instrumental for the continuance of this study, Dr. Doug Hamilton and Heather Allaway, lecturers at ISU; Yael Barr, and Ashot Sargsyan, from Wyle Laboratories and NASA Johnson Space Center; Pam Henderson and Dr. Jeff Benseler, from the Ohio University Clinic; and Dr. Ana Catarina de Medeiros Periotto from the Ministry of Health, Sao Paulo, Brazil. And special thanks to Mrs. Kathleen Rosendahl-Garcia, Sr. Scientist at KBRwyle and Clinical and Research Sonographer at NASA Johnson Space Center. She is proficient in remotely guiding astronauts through a variety of difficult clinical and research-based sonography procedures, and has contributed to develop and apply new concepts in telemedicine using ultrasound. Kat served as the sonographer for this experiment and mentored us through this journey, which we very much appreciate.

## REFERENCES

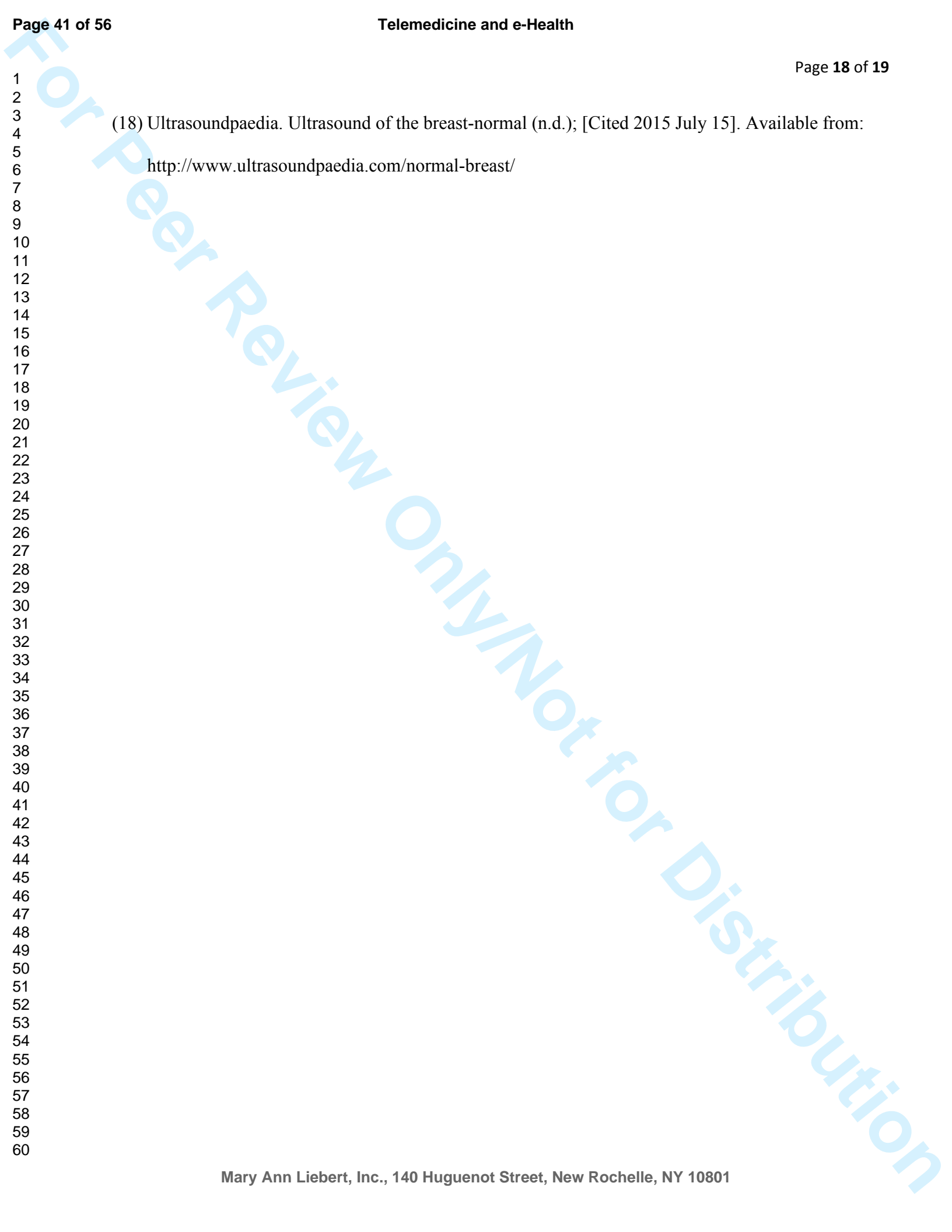
- 1  
2  
3  
4  
5  
6 (1) Arbeille P, Zul P, Saccomandi A, Ruiz J, Andre E, de la Porte C, Carles G, Blouin J, Georgescu M.  
7  
8 Teleoperated Echograph and Probe Transducer for Remote Ultrasound Investigation on Isolated  
9  
10 Patients (Study of 100 Cases) Telemedicine and e-Health. 2016; doi:10.1089/tmj.0186.  
11
- 12 (2) Barr YR, Bacal K, Jones JA, Hamilton DR. Breast cancer and spaceflight: risk and management.  
13  
14 Aviation, Space, and Environmental Medicine 2007; 78(4, Suppl.):A26-A37.  
15
- 16 (3) Gillis DB, Hamilton DR. Estimating outcomes of astronauts with myocardial infarction in  
17  
18 exploration class space missions. Aviation, Space, and Environmental Medicine. 2014; 83(2):79-91.  
19
- 20 (4) Griffiths, T. Breast ultrasound scanning technique. Sound Effects Educational Supplement 2000  
21  
22 [Cited 2015 July 20]. Available from: [http://www.a-s-a.com.au/Members/soundeffectsArticles/  
23  
24 \\_articles/BreastUltrasoundScanningTechnique%20march,%202000.pdf](http://www.a-s-a.com.au/Members/soundeffectsArticles/_articles/BreastUltrasoundScanningTechnique%20march,%202000.pdf)  
25  
26  
27
- 28 (5) Hamilton DR, Sargsyan AE, Martin DS, Garcia K, Melton SL, et al. On-orbit prospective  
29  
30 echocardiography on International Space Station crew. Echocardiography Wyle Periodicals, Inc.  
31  
32 2011; doi: 10.1111/j.1540-8175  
33  
34
- 35 (6) Hurst V, Peterson S, Garcia K, Ebert D, Ham D, et al. Concept of operations evaluation for using  
36  
37 remote-guidance ultrasound for exploration spaceflight. Aerospace Medicine and Human  
38  
39 Performance. 2015; 86(12):1034-1038.  
40  
41
- 42 (7) Kirkpatrick AW, Jones JA, Sargsyan A, Hamilton DA, Melton S, et al. Evaluating trauma  
43  
44 tomography for operational use in microgravity environment. Journal of Medicine. 2007 [Accessed  
45  
46 2015 July 10]. Available from: <http://ntrs.nasa.gov/search.jsp?R=20070023642>  
47  
48
- 49 (8) Lee C H, Dershaw D D, Kopans D, Evans P, Monsees B et al. Breast cancer screening with  
50  
51 imaging of breast imaging and the ACR on the use of mammography, breast MRI, breast  
52  
53  
54  
55  
56  
57  
58  
59  
60

- 1  
2  
3 ultrasound, and other technologies for the detection of clinically occult breast cancer. 2010;  
4  
5 DOI: <http://dx.doi.org/10.1016/j.jacr.2009.09.022>  
6  
7  
8 (9) Martin D, Caine T, Matz T, Lee S, Stenger M, et al. Virtual guidance as a tool to obtain diagnostic  
9  
10 ultrasound for spaceflight and remote environments. *Aviation, Space, and Environmental Medicine*.  
11  
12 2012; 83(10):995-1000.  
13  
14  
15 (10) NASA. Human research facility ultrasound on the International Space Station 2 (Ultrasound 2).  
16  
17 2015 [Cited 2015 July 1]. Available from: [http://www.nasa.gov/mission\\_pages/station/research/  
18  
19 experiments/749.html](http://www.nasa.gov/mission_pages/station/research/experiments/749.html)  
20  
21  
22 (11) OBGYN. Sonography of the Breast. Society of Diagnostic Medical Sonography's 17<sup>th</sup> Annual  
23  
24 Conference, Dallas, TX. 2000; 57-67, [Cited 2015 July 18]. Available from:  
25  
26 <http://www.obgyn.net/articles/sonography-breast>  
27  
28  
29 (12) Rafnsson V, Tulinius H, Jonasson J, Hrafnkelsson J. Risk of breast cancer in female flight  
30  
31 attendants: a population-based study. *Cancer Causes & Control* 2001; 12(2):95–101.  
32  
33  
34 (13) Reynolds P, Cone J, Layefsky M, Goldberg D, Hurley S. Cancer incidence in California flight  
35  
36 attendants, *Cancer Causes & Control* 2002; 13(4):317-324.  
37  
38  
39 (14) Sargsyan A, Melton S, Hamilton DR, Young J. The International Space Station ultrasound imaging  
40  
41 capability overview for prospective users. NASA, 2006; NASA/TP–2006–213731.  
42  
43  
44 (15) SIMTICS Healthcare. Ultrasound training breast. 2010 [Cited 2015 July 20]. Available from:  
45  
46 <https://www.youtube.com/watch?v=PCAnL9pauce>  
47  
48  
49 (16) Sonosite. M-Turbo Data Sheet. 2014 [Cited 2016 January 10]. Available from:  
50  
51 <http://www.iit.hr/Katalozi/SonoSite-M-Turbo%20Eng.pdf>  
52  
53  
54 (17) Tempkin BB. *Ultrasound scanning: principle and protocols*, 3rd ed. St. Louis, MO. W.B. Saunders  
55  
56 Elsevier; 2009.  
57  
58  
59  
60

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

(18) Ultrasoundpaedia. Ultrasound of the breast-normal (n.d.); [Cited 2015 July 15]. Available from:

<http://www.ultrasoundpaedia.com/normal-breast/>



1  
2  
3 **Address correspondence and reprint requests to:** Jackelynn P. Silva-Martinez, MS, International Space  
4 University, 1315 Nasa Parkway Apt #301, Houston, TX 77058. Email: [Mary Ann Liebert, Inc., 140 Huguenot Street, New Rochelle, NY 10801](mailto:j.silva-<br/>5<br/>6 <u>martinez@community.isunet.edu</u></a><br/>7<br/>8<br/>9<br/>10<br/>11<br/>12<br/>13<br/>14<br/>15<br/>16<br/>17<br/>18<br/>19<br/>20<br/>21<br/>22<br/>23<br/>24<br/>25<br/>26<br/>27<br/>28<br/>29<br/>30<br/>31<br/>32<br/>33<br/>34<br/>35<br/>36<br/>37<br/>38<br/>39<br/>40<br/>41<br/>42<br/>43<br/>44<br/>45<br/>46<br/>47<br/>48<br/>49<br/>50<br/>51<br/>52<br/>53<br/>54<br/>55<br/>56<br/>57<br/>58<br/>59<br/>60</p></div><div data-bbox=)