

Report From the Field

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Abbreviations:

FAST, focused assessment with sonography for trauma; PACS, Picture Archiving and Communication System; PLA(N), People's Liberation Army Navy; POCUS, point-of-care ultrasound

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Portable Ultrasonography Onboard Deployment in the PLA(N) Peace Ark Hospital Ship in Mission Harmony 2018

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Abstract

From June 28 to November 22, 2018, the Chinese People's Liberation Army Navy – PLA(N) – Peace Ark hospital ship had conducted Mission Harmony 2018, providing humanitarian medical assistance and carrying out international cooperation, in 4 Pacific island countries and 6 Central and South American countries. Compared with its application only in onshore outreach medical teams in the previous Mission Harmony, portable ultrasonography was used both onboard and onshore in Mission Harmony 2018. The purpose of this study was to assess the performance of onboard portable ultrasonography in PLA(N) Peace Ark hospital ship during Mission Harmony-2018, share our onboard working experience, and provide a reference for humanitarian assistance missions in the future. A retrospective review was performed on a cohort of patients checked by onboard portable ultrasonography. Patients' gender, age, the distribution of examined organs, and multiple applications of the portable ultrasonography were analyzed. Some limitations of portable ultrasonography on the mission and possible improvements in the future were also discussed. A total of 5277 cases (mean age: 43.74 years; range: 2 months–105 years) of ultrasound examinations were performed during the mission; among them, 3126 (59.2%) cases were performed by portable ultrasonography, including 3024 onboard cases and 102 onshore cases. The portable ultrasonography had been applied in many scenarios, for example, onboard emergency triage process, onboard bedside medical support, and onshore outreach medical service, which had become one of the indispensable auxiliary examination methods for its compatibility, portability, and flexibility. The onboard deployment of portable ultrasonography played a versatile and irreplaceable role in the humanitarian medical assistance and medical cooperation carried out by the PLA(N) Peace Ark hospital ship, and will contribute to such kind of missions in the future.

Introduction

From June 28 to November 22, 2018, the PLA(N) Peace Ark hospital ship ([Figure 1](#)) had conducted Mission Harmony 2018, providing humanitarian medical service and carrying out international cooperation, in 4 Pacific island countries and 6 Central and South American countries,^{1,2} namely, Papua New Guinea, Vanuatu, Fiji, Tonga, Venezuela, Grenada, the Common Wealth of Dominica, Antigua and Barbuda, Republic of Dominica, and Ecuador.

Ultrasound medical support is integral and significant to the mission for its flexibility and real-time and non-radioactive diagnosis.³ In the previous missions of providing humanitarian medical service and carrying out international cooperation conducted by Peace Ark, portable ultrasonography was only used by the onshore outreach medical teams⁴; whereas, during Mission Harmony 2018, 2 portable ultrasound apparatuses were deployed onboard and used both onboard and onshore.

As we found there were few detailed reports on ultrasonography in humanitarian assistance mission in literature view, we would like to review the ultrasonography work during the mission, especially the performance of onboard portable ultrasound apparatus, and share our working experience from a sonologist's perspective, so as to provide a reference for the improvements of ultrasonography work in future missions.



Figure 1. PLA(N) Peace Ark hospital ship in Mission Harmony-2018.

Narrative

Devices and Working Process

During Mission Harmony 2018, the onboard ultrasound department of the Peace Ark had a deputy chief sonologist, an attending sonologist, and a sonologist assistant. Considering the possible heavy workload in 10 countries and the demand of the onshore outreach medical team, we therefore carried 2 portable ultrasound apparatuses (Wisonic Clover60, Shen Zhen, China; and Mindray M7, Shen Zhen, China) aboard for their unique advantages of compatibility and portability in the limited onboard space, besides 1 already-installed onboard full-sized ultrasound apparatus. Each portable apparatus had a Low frequency probe (5 MHz) and a high frequency probe (12 MHz). The apparatus could provide multimodal imaging information, for example, brightness modulation, color Doppler, and pulse wave Doppler. All the ultrasound images and reports were co-evaluated by 2 experienced sonologists.

During the stay in the host countries, all the patients should go through preliminary screening before boarding the Peace Ark. Doctors onboard needed to sign a request form for ultrasound examination based on the patients' condition, then the sonologists performed these examinations and made reports accordingly. When the anesthetist planned to do a precise puncture operation, a sonographer would provide them with assistance using portable ultrasonography. In the case of an emergency, a sonologist should carry a portable ultrasound apparatus to the spot to assist diagnosis and treatment. Besides these ship-based medical services, the Peace Ark hospital ship also dispatched outreach medical teams to the outlying island, villages, and communities that were far away from the port. Usually, each medical team had 1 sonologist with a portable ultrasound apparatus.

The Performance of the Portable Ultrasound Apparatus on the Main Platform of the Peace Ark Hospital Ship

The Peace Ark handled 41 776 patients (age range: 2 months–111 years). A total of 5277 patients (mean age: 43.74 years; age range: 2 months–105 years) with 19 776 organs received ultrasound examination; among them, 3126 (59.2%) patients with 11 652 organs

were checked by a portable ultrasound apparatus. The cases handled by a portable ultrasound apparatus were related to the digestive system ($n = 1283$), urinary system ($n = 676$), female genital system ($n = 757$), thyroid gland and other superficial soft tissue lesions ($n = 361$), peripheral vessels ($n = 42$), and thoracic organs ($n = 7$) (Table 1).

A total of 12 476 examinations were performed due to most of the patients having received an ultrasound examination for 2 or more regions (organs) of the body (Table 2). In total, 53.5% of the ultrasonography were done for a kidney check; among them, renal stone was found in 585 cases. In the ultrasonography of the digestive system, 627 cases of fatty liver and 342 cases of gallstone (polyps) were detected; the number of lipomas (postoperatively confirmed by the onboard pathology department) was 107 out of 129 superficial masses examined by palpation (82.9%).

The Performance of a Portable Ultrasound Apparatus in the Onshore Outreach Medical Team

During the 9 deployments of onshore outreach medical team, the sonologist carried out 102 person/times on 370 organs and ultrasonographic examinations in the outlying island, villages, and communities, including 10 cases in the Vatulele island of Fiji and 58 cases in Carriacou island of Grenada. All of the ultrasonography was on the abdomen; among them, fatty liver was found in 23 cases (22.5%), renal stone was seen in 26 cases (25.5%), and 15 cases (14.5%) of gallstone were detected; the number of myoma of the uterus was 10 out of 102 examined cases (9.8%). In addition, 7 cases (6.9%) of inguinal hernia were diagnosed.

Focused Assessment with Sonography for Trauma (FAST)

The focused assessment with sonography for trauma (FAST) was performed in the China-Papua New Guinea joint emergency medical rescue drill.⁵ In the drill, the simulated patients with unstable hemodynamics underwent FAST.⁶ The patients with positive signs of pleural hemorrhage and/or abdominal hemorrhage were then quickly transferred into preoperative preparations.

Table 1. Cases distribution of portable ultrasonography examinations in Mission Harmony 2018

Country Name (In visiting order)	Cases Examined by Portable Ultrasound						Total
	Urinary System	Digestive System	Female Genital System	Thyroid Gland, Superficial Soft Tissue Lesions	Peripheral Vessels	Thoracic Organs	
Papua New Guinea	43	79	72	42	0	1	237
Vanuatu	39	78	86	34	2	0	239
Fiji	71	187	127	33	9	1	428
Tonga	47	139	69	45	3	0	303
Venezuela	58	86	49	27	5	1	226
Grenada	86	167	79	31	2	1	366
Common Wealth of Dominica	77	113	82	42	5	1	320
Antigua and Barbuda	81	127	63	31	3	0	305
Republic of Dominica	79	110	56	35	2	1	283
Ecuador	95	197	74	41	11	1	419
Total	676	1283	757	361	42	7	3126

Table 2. Number of portable ultrasonography examinations and positive findings in Mission Harmony 2018

Country Name (In visiting order)	Examination Findings Number (% of Total)						Total Positive Number
	Renal Stone	Fatty Liver	Gallstone (Polyps)	Superficial Lipoma	Other Findings	Normal	
Papua New Guinea	43(18.1%)	39(16.5%)	26(11.0%)	13(5.5%)	23(9.7%)	93(39.2%)	144(60.8%)
Vanuatu	34(14.2%)	35(14.6%)	37(15.5%)	9(3.8%)	27(11.3%)	97(40.6%)	142(59.4%)
Fiji	64(14.9%)	92(21.5%)	58(13.6%)	13(3.1%)	35(8.2%)	166(38.8%)	262(61.2%)
Tonga	46(15.2%)	69(22.8%)	40(13.2%)	15(5.0%)	24(7.9%)	109(36.0%)	194(64.0%)
Venezuela	65(28.8%)	48(21.2%)	25(11.1%)	7(3.1%)	21(9.3%)	60(26.5%)	166(73.5%)
Grenada	82(22.4%)	91(24.9%)	31(8.5%)	8(2.2%)	17(4.6%)	137(37.4%)	229(62.6%)
Dominica	62(19.4%)	57(17.8%)	27(8.4%)	7(2.2%)	16(5.0%)	151(47.2%)	169(52.8%)
Antigua and Barbuda	51(16.7%)	64(21.0%)	31(10.2%)	12(3.9%)	13(4.3%)	134(43.9%)	171(56.1%)
Dominican Republic	67(23.7%)	53(18.7%)	25(8.8%)	8(2.8%)	11(3.9%)	119(42.0%)	164(58.0%)
Ecuador	71(16.9%)	79(18.9%)	42(10.0%)	15(3.6%)	28(6.7%)	184(43.9%)	235(56.1%)
Total	585(18.7%)	627(20.1%)	342(10.9%)	107(3.4%)	215(6.9%)	1250(39.9%)	1876(60.0%)

Point-of-Care Ultrasound (POCUS)

A total of 5 emergency cases (including 1 simulation case in a drill) were rapidly diagnosed by the portable ultrasound apparatus taken at sickbed. In 1 case, a patient suddenly suffered from acute respiration failure when waiting for clinical consultation at the outpatient area of the hospital ship. Upon the call, the sonologists immediately rushed to the sickbed with a portable ultrasound apparatus and diagnosed the person as having massive pericardial fluid and pleural effusion.

Portable Ultrasound Guided Puncture and Nerve Block Anesthesia

One case of ultrasound-guided jugular vein catheterization and 4 cases of nerve block anesthesia were successfully performed. In the Republic of Dominica, a patient showed hyperpyrexia, hypotension, and tachycardia 2 hours after the onboard operation of urinary tract dilation. The anesthetists considered that septic shock might be caused by urinary infection. As the patient's veins tended to collapse due to septic shock, it was difficult to administrate to venous route, and the jugular vein catheterization was needed.

When the catheterization was done promptly and precisely with the guidance of a portable ultrasound, the early and rapid fluid resuscitation was ensured. Four other cases of nerve block by using the portable ultrasound apparatus were also successfully completed, that is, brachial plexus block, femoral nerve and obturator nerve block, ischiatic nerve block, and common peroneal nerve block, which assisted a resection of upper limb neurinoma, resection of great saphenous vein aneurysm, resection of a cyst in popliteal space, and a plastic surgery of toe malformation, respectively. The lower limbs nerve block had never been done before onboard the Peace Ark.

Academic Exchange and Workshop

Academic exchange and workshop were also an important part of international humanitarian assistance and medical cooperation. We successfully held 2 academic exchanges and workshops in Papua New Guinea and Ecuador on FAST and the application of ultrasound-guided nerve block anesthesia and gained very positive effects in bilateral medical cooperation.

Discussion

Distribution of Findings in Ultrasonography

In Mission Harmony 2018, many host countries were in regions with high incidence of fatty liver and renal stones,⁷ so the proportion of positive findings in ultrasonography was up to 20.1%, taking 18.7% of the total number of patient (see Table 2). The urinary system, digestive system, female genital system, and thyroid gland and other superficial soft tissue lesions were the main focuses of the ultrasonography in this 10-country mission. Among them, the total number of digestive system ultrasonography was 1283 (41.0%), which ranked top among all (see Table 1).

Effective Measures and Working Experience Gained from the Mission

No matter in the work of onboard emergency triage process, onboard bedside medical support, or onshore outreach medical service, the portable ultrasonography had become one of the indispensable auxiliary examination methods for light weight, compatibility, and portability, especially in the limited working conditions, for example, small onboard cabin, outlying islands, villages, and communities in remote areas. The FAST, as 1 step in the triage process, has been proved as an essential component of providing quick and rapid treatment to the patients in disaster or wounded in war. POCUS can provide more flexible service at bedside to support diagnosis in emergency cases, by preparing portable ultrasound apparatus as one of the emergency medical equipment in the onboard emergency area. Besides supporting emergency treatment at bedside, portable ultrasound apparatus can also be used for guiding the nerve block anesthesia. Compared with spinal anesthesia or general anesthesia, it can reduce postoperative pain, potential complications, and systemic effects. Moreover, it can significantly shorten the time of postoperative rehabilitation, which was one of the indispensable links in rapid rehabilitation surgery.⁸ In addition, the working experience of using portable ultrasonography in onshore outreach medical service can also be a reference for the on-field medical care in disaster and war.

Sonologist Operating Skill Preparation

Based on the statistical results of the Mission in 2018, we found it is necessary for sonologists to have more experience and get more training before their onboard work, especially on examining the urinary system, digestive system, female genital system, and thyroid gland and other superficial soft tissue lesions regularly, to provide a high-quality service in humanitarian assistance missions.

During a disaster or wartime, mass casualties will be transported to medical facilities, for example, hospital ship and medical post of outreach medical team, which surely would be a heavy workload for sonologists. To meet the needs, the sonologists or even paramedics can do a short-time intensive training on FAST for efficient triage and emergency diagnosis.

Limitations

Although the ultrasonography work during the mission had achieved many successes, there were some limitations in our work and study. First, the 2 portable ultrasound apparatuses were not equipped with a cardiac probe, thus all cardiac ultrasound examinations had to be done on the only 1 onboard full-sized apparatus. If the portable ultrasound apparatus could conduct echocardiography in peak time, patients would not wait for a long time. Second,

contrast materials were not available onboard; therefore, the contrast-enhanced ultrasound scans could not be performed. As this technology is now widely used in differentiating benign and malignant nodules of the thyroid, liver, breast, prostate, and lymph nodes, and so forth, this limitation affected the accuracy of an ultrasound diagnosis, in some cases, for example, occupying lesions. Third, the portable ultrasound apparatuses would be suggested to connect with the Peace Ark onboard the Picture Archiving and Communication System (PACS), which could facilitate valuable medical images collection and doctors' communication. Although one of the portable devices was equipped with a distance diagnostic system, the distance expert consultation and education were not carried out during the mission due to the limitation of the local Internet service. Fourth, the sample size for this study was not sufficient to holistically and comprehensively reflect the local public medical condition, due to the short stay in each country. In addition, the nature of our research was descriptive and did not adopt any complicated statistical methods. Future research should include more patient details.

Conclusion

The onboard portable ultrasonography played a versatile and irreplaceable role in the humanitarian medical assistance and medical cooperation in Mission Harmony 2018. For its light weight, compatibility, and portability, the onboard portable ultrasonography can provide real-time, rapid, and flexible support to the onboard triage process, emergency medical treatment, bedside anesthesia procedure, onshore outreach medical service, and so forth. We believe portable ultrasonography will contribute more in international humanitarian medical service and medical cooperation conducted by the PLA(N) Peace Ark hospital ship or other medical facilities in the future.

Data Availability Statement. The data sets analyzed in this study are available at Changzheng Hospital, Second Military Medical University, Shanghai, China.

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Ethical Standards. All data collections and reviews were approved by our bioethics commission. All medical practices were approved by the ministries of health in the host countries. Oral informed consents for data collection were obtained from all the patients before collecting data. This study was approved by the Scientific Investigation Board of Second Military Medical University, Shanghai, China.

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