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Expanding the Horizons of Interventional Radiology: Training Analog Astronauts for Percutaneous Drainage in Preparation for Deep Space Exploration

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To the Editor,

The pursuit of space exploration presents unique challenges, particularly when it comes to ensuring the health and well-being of astronauts on extended missions beyond Earth's orbit. As missions to the Moon, and beyond to Mars, are planned, the need for medical capabilities in outer space is becoming increasingly critical. In this context, interventional radiology (IR) has emerged as a promising field for addressing medical emergencies during space travel [1].

One essential step in bringing IR into the realm of space exploration is to first test it during Moon/Mars analogue missions on Earth. Analogue astronauts (AA) not only serve as critical participants in facing the challenges of living and working in a simulated Martian base but are also extensively trained in medical procedures vital for space missions [2]. In preparation for the Asclepios III mission consisting in a simulation designed to assess astronauts' autonomy in conditions simulating distant space travel, resembling an environment akin to life at the South Pole of the Moon [3], an ambitious project was led by the French Society of Radiology (SFR), the French Space Agency (CNES), and the French Institute for Space Medicine and Physiology (MEDES) to train AA to perform percutaneous drainage procedures using ultrasound guidance and the Mars Interventional Radiology Tool Box (MITBO) tailored for deep-space travel [1].

The training program, designed to prepare these AA for potential medical scenarios during their missions, consisted of a comprehensive curriculum. It encompassed clinical training, technical proficiency in ultrasound and image recognition, and familiarization with the necessary

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Fig. 1 ASCLEPIOS III project. **A** Practical training involving ultrasound practice and the performance of multiple drainages under the supervision of a senior interventional radiologist (JF) **B** The team of six astronaut analogues for the Asclepios III mission. **C** Practical application during the mission, with each astronaut required to independently perform a drainage procedure using their educational resources. The procedures were recorded for external evaluation

equipment and drainage techniques. Importantly, the program emphasized practical hands-on experience with ultrasound-guided drainage procedures.

As part of the evaluation process, 6 AA completed a pre-test to assess their baseline knowledge and skills. After completing the e-learning component of the training program, 50% of these AA felt ready to perform a drainage procedure, achieving a pre-test score of 77.65%. Following their practical on-site training, the AA achieved a post-test score of 94.12% and all expressed faith in their ability to perform a drainage procedure in space.

Two months after training, the culmination of this effort was tested during the Asclepios III mission. In this mission, the 6 AA encountered a medical scenario simulating a case of cholecystitis, involving a phantom that mimicked a gall bladder requiring drainage. Equipped with the MITBO, each AA had to perform percutaneous drainage under ultrasound guidance on a simulation phantom in complete autonomy without medical support from Earth-based expert (Fig. 1). They had at their disposal the same educational resources and support materials they had utilized during their initial training. During these hands-on sessions, the AA were required to demonstrate their proficiency in various aspects of the drainage process. This included accurately identifying the target site for catheter insertion, placing the needle precisely under ultrasound guidance, and successfully threading the catheter into the collection point using the historical Seldinger technique [4], thus mirroring real-life interventional radiology procedures.

Although not all the AA achieved the same level of proficiency, with two individuals encountering challenges that highlighted the complexities of performing medical procedures in space, the mission emphasized the potential of interventional radiology in addressing critical medical issues during deep space travel.

The outcomes of this training and mission demonstrate the capacity of astronauts to learn advanced medical procedures and the critical role that practical hands-on experience plays in building their proficiency. It is becoming increasingly obvious that interventional radiology, with its minimally invasive techniques and portable equipment, can serve as a valuable asset to address medical emergencies in the immensity of space. In the coming year, we look

forward to embarking on a groundbreaking endeavor: the practice of these skills in a zero-gravity environment, further pushing the boundaries of medical capabilities beyond Earth's orbit.

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Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval This article does not contain any studies with human participants or animals performed by any of the authors.

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Consent for Publication Consent for publication was obtained for every individual person's data included in the study.

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