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Bringing Interventional Radiology to Mars!

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Abstract At present, astronauts on space missions can get medical assistant from Earth. In the future, deep space missions such as missions to Mars will delay communication with physicians on Earth, making it impossible to get immediate support in urgent medical situations. On the spaceship, a polyvalent physician-astronaut could mainly perform small surgery and traumatology procedures. Interventional Radiology (IR) allows minimally invasive interventions and requires small devices. In these conditions of space constrains, IR presents significant benefits. To guarantee the technical realization of specific medical interventions during deep space missions, a team composed of interventional radiologists and space engineers, is developing the IR toolbox. The development of the toolbox intents to minimize the volume/weight of medical devices and to ensure the safety requirements for the crew. New scenarios of IR interventions have been developed to adapt the interventions to the spatial context, making possible the treatment of pathologies that are otherwise, on Earth, optimally treated surgically. Interventional radiology has a major role to play in the management of acute medical problems which may occur in the future story of deep space missions to the Moon, and further to Mars.

Keywords Interventional radiology · Spaceflight · Interventional radiology toolbox · Medical care on the space

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Bringing Interventional Radiology (IR) to Mars is the new challenge of interventional radiologists.

Why

When astronauts are on missions within Earth's orbit, for example, on the International Space Station (ISS), the medical risk is well controlled. The crewmembers can get direct support from physicians located on Earth whenever required via teleconference. In acute cases, the astronauts could be back on Earth to get treated in a hospital within 24 h. During future missions to Mars, as communication could be delayed by up to 45 min, real-time medical support will not be an option. In addition, the evacuation of the sick crewmember will become impossible, implying treating the problem on the spot. Another consideration will be the limitation of bringing heavy or large surgical equipment due to space and weight restrictions of spaceflight.

During deep space missions, a polyvalent physician-astronaut could mainly perform small surgery and traumatology procedures. Under these conditions, IR presents significant benefits [1–3]. A small and light ultrasound device is easily transportable and allows to access deep organs, to put a needle and place a small catheter rapidly and safely under local anesthesia. Many basic IR procedures use a fairly standard and minimal set of tools: needle, wire, catheter, etc.

How

Under an initiative led by the French Society of Radiology (SFR), the French Space Agency (CNES), and the French Space Medicine and Physiology Institute (MEDES), a team composed of eighteen interventional radiologists and space engineers is developing the Interventional Radiology toolbox for deep space travel. The objective is to ensure the technical realization of eleven specific medical interventions anticipated by NASA during deep space missions, such as pneumothorax, urinary retention, hematoma, etc. (Table 1). The development of the toolbox focuses on respecting the constraints of bringing material to space stations, such as minimizing the volume/weight of medical devices and ensuring the safety requirements for the crew. New scenarios of IR interventions have been developed to adapt the interventions to the spatial context, making possible the treatment of pathologies that are otherwise, on Earth, optimally treated surgically such as tracheotomy.

Performing interventions in microgravity during space travel, or partial gravity once on Mars, is a challenge. Everything takes on another very specific dimension: objects float in space, so everything must be attached. Another concern is to avoid contamination of the station; for example, puncturing an abscess has to be done in a perfectly closed system to collect fluids.

Table 1 Medical scenarios suitable to treatment by interventional radiology at deep space

Body region	Disorder
Thorax	Pleural effusion
	Pneumothorax
	Cardiac tamponade
	Abscess
Abdomen	Cholecystitis
	Renal colic
	Ascites
	Abscess
Pelvis	Urinary retention (inappropriate for catheterization)
	Abscess
General	Hematoma

When

The IR toolbox is already taking its first step on the Moon: it will be part of the analog mission Asclepios III, a lunar base simulation “launching” in summer 2023.

Analog missions intend to recreate the harsh extra-terrestrial conditions in isolated, confined, and extreme environments and involve crews of so-called analog astronauts. Such simulations on the ground serve to test features of spaceflight missions, such as emergency medical procedures and hardware.

The analog astronauts will have to deal with a clinical scenario of acute urinary retention, with failure of a urethral catheterization, based on a real episode that occurred during an orbital flight and required an emergency evacuation to Earth.

With the IR toolbox, each analog astronaut will have to perform a medical intervention under ultrasound guidance on a phantom for simulation, according to the techniques of interventional radiology (suprapubic catheterization, catheter placement according to the Seldinger technique).

This technique is then applicable to a large number of other pathologies as an alternative to surgical techniques that are impossible to perform in space flight conditions, for example, the drainage of a digestive abscess or a kidney retention involving the vital prognosis.

While space missions might be a driver for the development of such a minimized toolbox and IR-adapted procedures tailored to non-medical operators, this toolbox may also improve care in austere environments on Earth. A versatile, light toolbox and portable ultrasound could be used in some specific conditions, such as in areas far from any hospital in emerging countries.

Interventional radiology has a major role to play in the management of acute medical problems which may occur in the future story of deep space missions to the Moon, and further to Mars.

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