First Experiences with the Whole-Body Dot Engine

Stephan Zangos; Daniel Alzmann; Boris Schulz; Thomas J. Vogl

Institute for Diagnostic and Interventional Radiology, University Hospital Frankfurt, Frankfurt/Main, Germany

In clinical routine, whole-body magnetic resonance (MR) imaging is highly beneficial in many scenarios, such as bone marrow alterations, infectious or rheumatic diseases, and evaluation of solid tumor spread-out. This technique reduces the need for separate, and therefore time-consuming dedicated examinations, and necessary therapy can be started earlier.

In the past, whole-body MR imaging within a single examination had not been feasible because of device-related limitations. One reason was the measurement volume of the scanner that was restricted by the number of coils and RF channels. Another reason was the repositioning of the patient and coils for a whole-body examination.

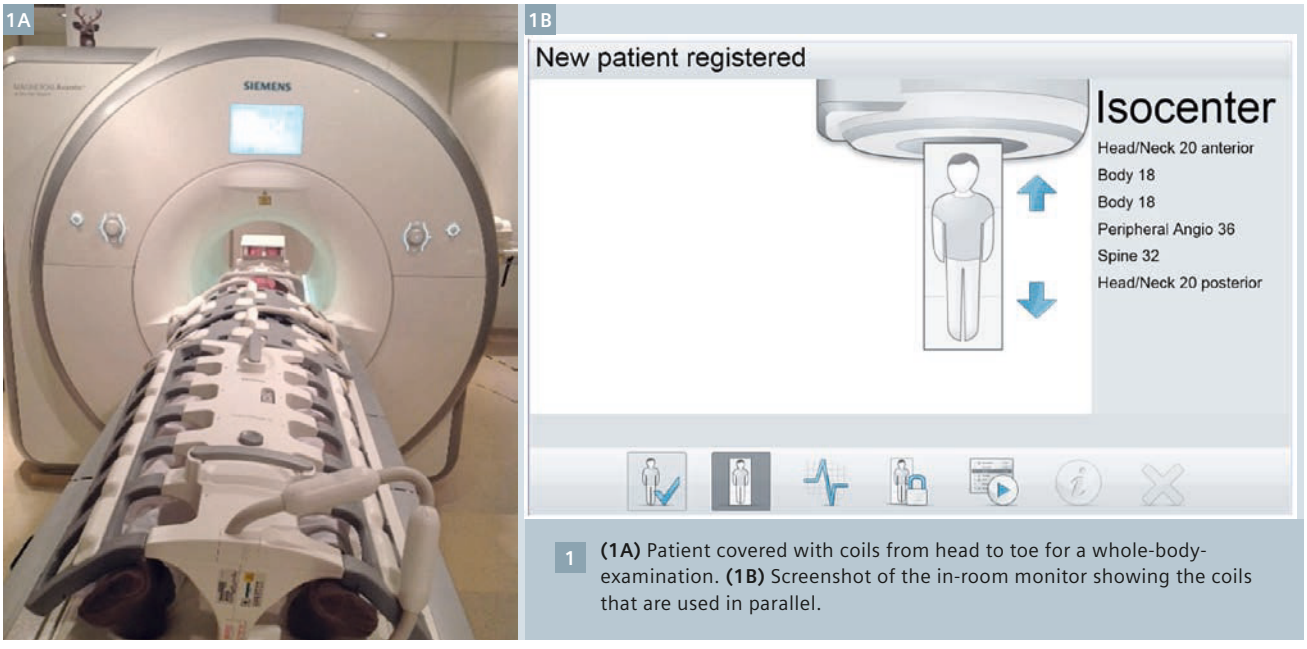
Subsequently, self-developed set-and-go protocols were used for whole-body examinations. However, this meant that all examination areas needed to be manually changed, which was time-consuming. Thus, the risk of incorrect adjustments leading to insufficient examinations increased.

With the latest scanner generation, however, such technical limitations are no longer relevant. Today, Tim 4G (Total imaging matrix technique), enables whole-body examinations of a scan range of up to 204 cm without any repositioning of the patient or coils. The patient is examined in the supine position with arms positioned tight against the body*.

Selection of dedicated coils is advisable according to the study regions: The head/neck coil, two body coils, and if necessary, the peripheral angio coil have to be positioned on top of the patient and are combined with the spine coils that are integrated in the table. In particular, the extensive use of strapped coils, especially in combination with the head/neck-coil, can cause discomfort in claustrophobic patients. Attaching the coils takes about two minutes.

Additionally, Dot (day optimizing throughput) workflow engines are available for various body regions. These are routinely used in our department, especially for neuro, spine, heart, and liver diagnostics. The Dot engines offer automatic adaptation of the study regarding anatomical and physical abilities of patients and dedicated sequences for an optimal imaging result. Because the field-of-view (FOV) is automatically adjusted, the number of slices and study region, as well as quick planning and execution of the examination, can be performed under standardized conditions. The intuitive graphical user interface of the Dot engines allows less experienced technologists to safely perform complex MR studies in our clinic.

* Please note that dangerous current loops may be generated when parts of the patient's body touch. These loops may lead to burns or increase the probability of simulations. In order to prevent potential current loops, ensure that the patient is positioned with proper distance between parts of the body.



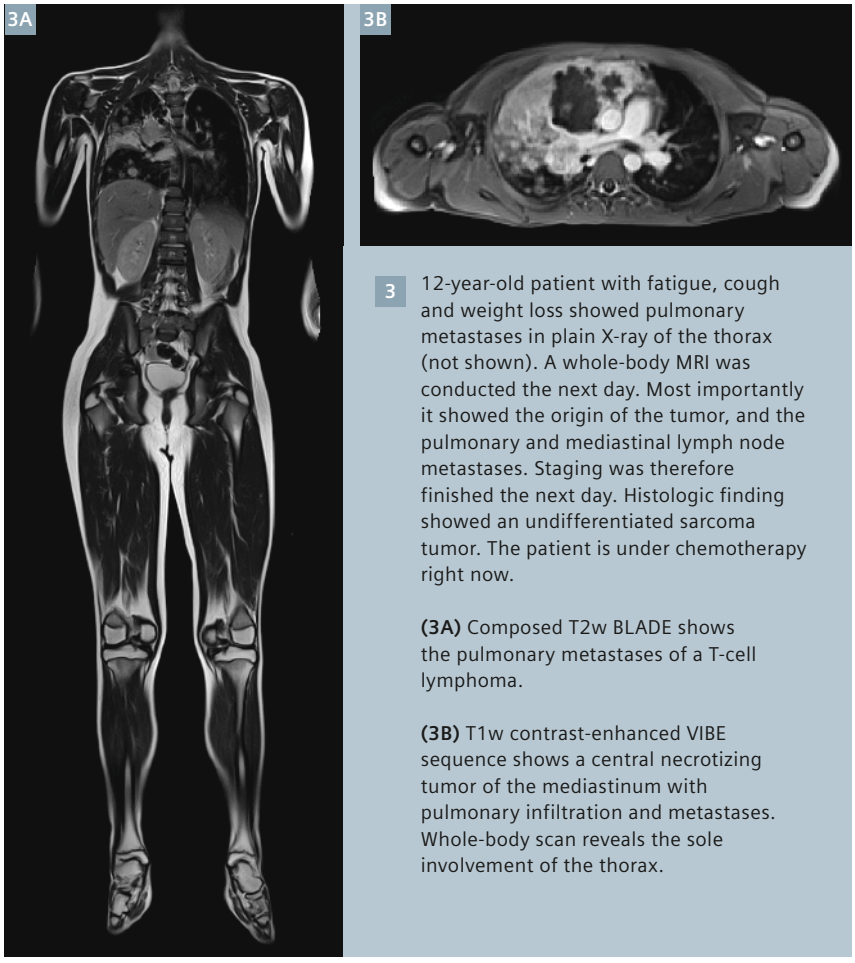
1 **(1A)** Patient covered with coils from head to toe for a whole-body-examination. **(1B)** Screenshot of the in-room monitor showing the coils that are used in parallel.

Whole-Body Dot Engine

Whereas in the past the Abdomen Dot Engine could perform auto-segmentation of only the liver, today the Whole-Body Dot Engine[1] covers a much larger examination field. It facilitates planning of multi-station examinations using extensions of the known AutoCoverage and AutoTiming mechanisms towards a multi-station examination. Once the patient is registered within the system, a fast view localizer is performed.

The localizer typically covers the anatomy from the head to the middle of the thighs and it is used to automatically segment different body regions such as chest, abdomen and pelvis. The localizer is performed with breath-holding and automatic breathhold commands. As a result of the segmentation the position and spatial extent of the different body regions are known and can be used to automatically adjust the FOV and number of slices of the multi-station examinations. The suggested coverage of the multi-station examinations is displayed in the graphical user interface of the scanner and can be modified by the technologist if necessary. The Whole-Body Dot Engine instantly estimates the optimal FOV in patients taller than 150 cm without the need for repositioning. But even with shorter patients, the study region can be easily adapted by using the graphical interface. In particular, the planning of thorax or abdomen examinations is now extremely easy and can be scheduled by the technologist intuitively in the same way as in computed tomography (CT). The simple adaptation of the study regions may significantly save time, in particular, during the planning of large study areas. Furthermore, an additional focus within a region can be chosen, and dedicated study protocols can be inserted. Multiple investigation strategies can be implemented in one protocol so that searching for the correct examination protocol in the sequence tree can be omitted. This includes, for example, dynamic examinations of the liver, MR angiography, or detailed regional study protocols to answer specific questions.

2 Screenshot showing the easy adaption of the examination coverage and the focus region using the new Whole-Body Dot Engine[1].



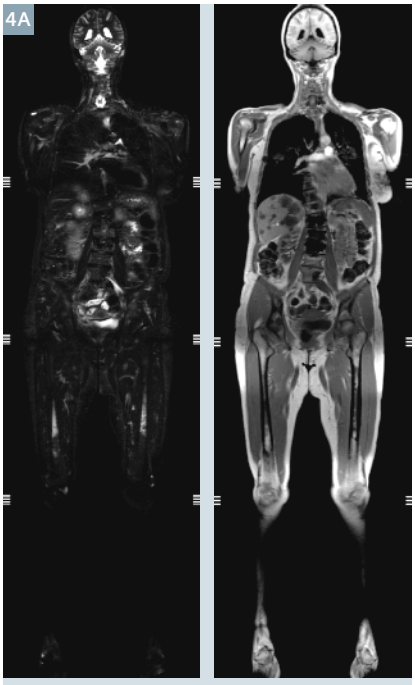
3 12-year-old patient with fatigue, cough and weight loss showed pulmonary metastases in plain X-ray of the thorax (not shown). A whole-body MRI was conducted the next day. Most importantly it showed the origin of the tumor, and the pulmonary and mediastinal lymph node metastases. Staging was therefore finished the next day. Histologic finding showed an undifferentiated sarcoma tumor. The patient is under chemotherapy right now.

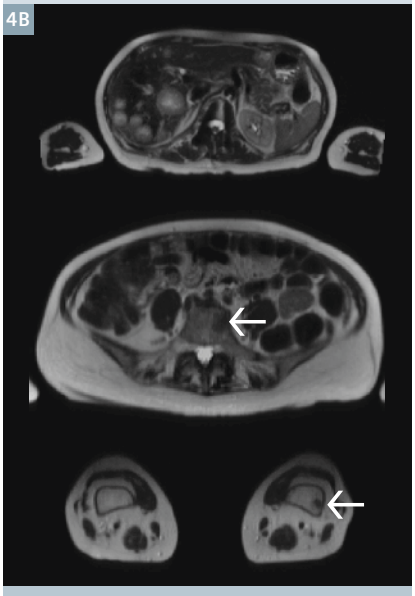
(3A) Composed T2w BLADE shows the pulmonary metastases of a T-cell lymphoma.

(3B) T1w contrast-enhanced VIBE sequence shows a central necrotizing tumor of the mediastinum with pulmonary infiltration and metastases. Whole-body scan reveals the sole involvement of the thorax.

[1] WIP, the product is currently under development and is not for sale in the US and in other countries. Its future availability cannot be ensured. The product is not yet licensed for sale in Canada, in accordance with Canadian Law. Performance claims have not been reviewed by Health Canada, and are subject to change. Its future availability cannot be guaranteed.

The automatic voice commands allow an optimal scan process, ensuring the synchronized timing of breathing and scanning via breathholding techniques. Selection of language is possible, so that the





4 54-year-old female with newly diagnosed non-small cell lung cancer. Whole-body examination was performed for staging before systemic chemotherapy. These images were the basis for the follow-up after chemotherapy.

(4A) Coronal T2w HASTE TIRM and corresponding T1w FLASH sequences document liver and bone metastases in different areas.

(4B) Axial HASTE sequence shows liver and bone metastases of the lumbar vertebra and the femur.

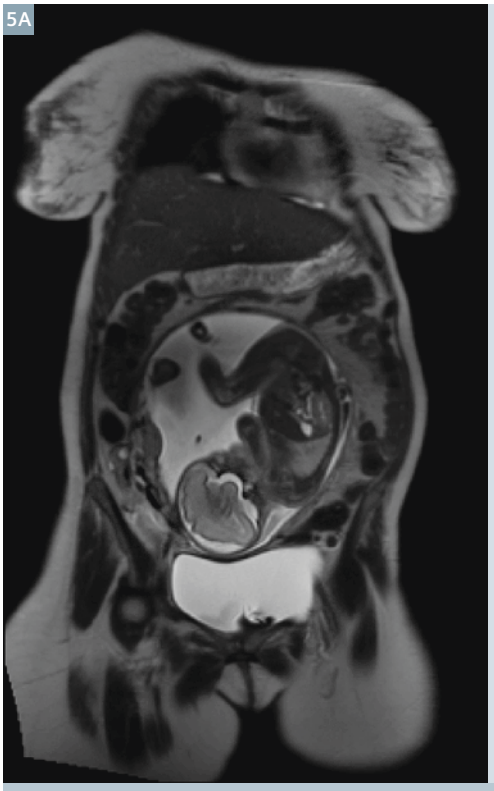
breathing commands can be understood by all patients, thereby reducing respiratory artifacts. The timing after contrast administration is now performed in a way analogous to CT scanning by using automatic bolus detection. Therefore, image acquisition at the correct point in time for dynamic contrast phases is more reproducible.

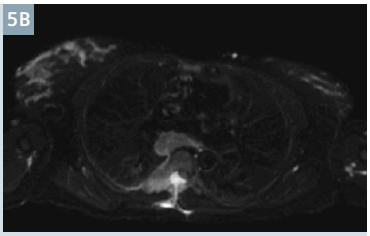
The Whole-Body Dot Engine provides fast and robust image quality across all patients, with fewer errors or need of repeated examinations. It ensures that all stations of a multi-station examination are performed with consistent field-of-view and spatial resolution while simultaneously obeying the patient's breathhold capability. This offers more comparable results through standardization, especially for follow-up examinations. The Whole-Body Dot Engine was adapted to our specific departmental standards by inserting our routinely used and familiar sequence protocols.

Overall, the Whole-Body Dot Engine offers the technologist a much simpler and intuitive guidance, analogous to methods used in CT examinations. As a result, technologists no longer need to fear complex examinations.

Conclusion

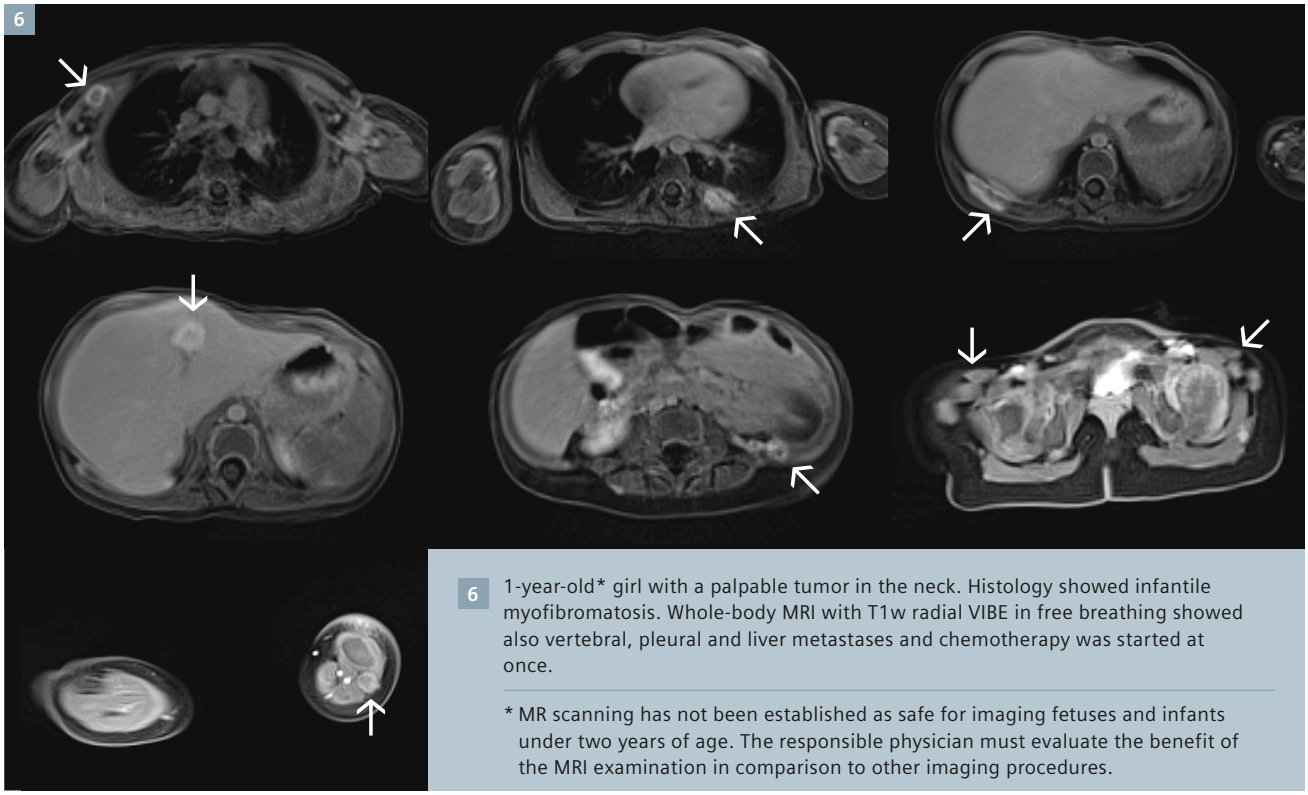
The Whole-Body Dot Engine allows easy implementation and standardization and consistent MR imaging from head to toe. Furthermore, the study protocol performed can easily be adapted to individual clinical indications and MR-sequences.





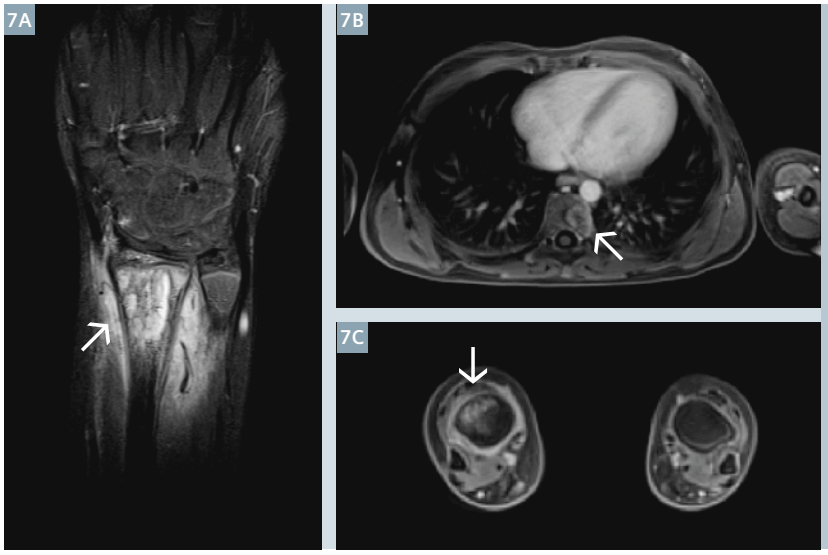
5 31-year-old female with 25 weeks gestation. The patient had a laminectomy after rapidly progressive paraparesis with spinal cord compression. Due to a still unclear histological finding whole-body MRI was performed to evaluate the spread. In the further course tuberculosis has been diagnosed and treated successfully.

(5A) Composed T2w HASTE sequence showed the current state of pregnancy with regularly developed fetus. **(5B)** Axial T2w HASTE TIRM sequence showed a residual infiltration of the costa and the posterior mediastinum. Whole-body MRI showed no further foci. **(5C)** Additionally conducted high-resolution study to assess the spine as a target region after surgery.



6 1-year-old* girl with a palpable tumor in the neck. Histology showed infantile myofibromatosis. Whole-body MRI with T1w radial VIBE in free breathing showed also vertebral, pleural and liver metastases and chemotherapy was started at once.

* MR scanning has not been established as safe for imaging fetuses and infants under two years of age. The responsible physician must evaluate the benefit of the MRI examination in comparison to other imaging procedures.



7 T1w SE FS sequence of a 10-year-old female with osteomyelitis of the radial bone of unknown origin.

Whole-body MRI with T1w radial VIBE in free breathing showed additional lesions in a vertebra **(7B)** and the right tibial bone **(7C)**. Based on the acquired images diagnosis of a chronic recurrent osteomyelitis could be made, and other foci of infect could be excluded.

Contact

Prof. Dr. med. Stephan Zangos
Institute for Diagnostic and Interventional Radiology
University Hospital Frankfurt
Theodor-Stern-Kai 7
Haus 23c
60590 Frankfurt am Main
Germany
Phone: + 49 (0)69 6301-87287
Fax: +49 (0)69 6301-7288
zangos@em.uni-frankfurt.de