Potential Pitfalls in Chest Diffusion Weighted Imaging

Yasuyuki Kurihara
Masaki Matsusako
Ryo Miyazawa
Takeshi Wada
Jay Starkey

Department of Radiology, St. Luke’s International Hospital
The authors have no conflict of interest to disclose with respect to this presentation.
Diffusion–weighted imaging (DWI) is beneficial in differentiating between malignant and benign lesions on the basis of information about tissue cellularity [1-4]. Currently DWI is commonly included in routine protocols for body magnetic resonance imaging (MRI); thus, abnormal findings in unexpected locations can be observed even in the thorax. However, these abnormalities are not always because of malignant or metastatic lesions. The reported sensitivity and specificity of DWI for intrapulmonary malignancy range from 0.7 to 0.89 and from 0.61 to 0.97, respectively [4-8], suggesting that there should be a significant number of false-positive and false-negative findings on DWI. The purpose of this pictorial review is to describe and illustrate the potential pitfalls associated with the interpretation of chest DWI findings that we encountered over the past decade of daily practice.
Normal Structures
Bone marrow

Chest DWI frequently shows hyperintense signals for ribs, thoracic spines, and the sternum. Hematopoietic marrow has a much higher signal intensity than that in fatty marrow [9], because of greater diffusion and it decreases with age [10]. This could lead to false-positive findings or even unjustified upstaging of malignancies [11]. Actually, there is much individual variation in the distribution of hematopoietic marrow. Extra attention should be given to the evaluation of bone metastasis based on DWI findings.

15-year-old boy with normal bone marrow. The hematopoietic marrow of the bony thorax is of much higher signal intensity. It changes into fatty marrow with age and loses signal intensity.
Normal lymph nodes are hyperintense on DWI. Although normal mediastinal lymph nodes are not clear on DWI, probably because of slight blurring due to free breathing and the use of a noncardiac gating method, axillary and chest wall lymph nodes are prominent. Therefore, it is difficult to differentiate metastatic lymph nodes from normal lymph nodes, and the apparent diffusion coefficient (ADC) values are not useful for differentiation [12].

64-year-old woman with normal lymph nodes.
A. DWI shows hyperintense axillary lymph nodes on both sides.
B. T1-weighted image shows normal axillary lymph nodes with hilar fatty structure.
The spinal cord is markedly hyperintense on DWI. At the thoracic inlet, DWI also shows hyperintensity of the brachial plexus [13], which mimics supraclavicular lymphadenopathy.

52-year-old woman with normal brachial plexus. DWI shows hyperintense band-like structures in bilateral supraclavicular areas.
Although water molecules in the vessels are well mobile and easily lose signal with diffusion sensitizing gradients, very slow-flowing blood could demonstrate hyperintense structures on DWI. In chest DWI, we sometimes encounter slow-flowing-related high signal in the jugular veins, the superior vena cava, and the azygos vein.

67-year-old man with normal azygos vein.
DWI shows high signal intensity at the transverse portion of the azygos arch.
Sagittal reformatted images have frequently demonstrated slightly hyperintense linear structures in front of the spines. DWI demonstrates high signal intensity of the esophageal mucosa caused by high cellularity of the bowel mucosa [14].

52-year-old woman with normal esophagus.
A. Sagittal DWI shows slightly high signal intensity along the esophageal mucosa in front of the spine.
B. Sagittal T1-weighted image shows a normal esophagus in front of the spine.
Normal DWI usually shows hyperintense adrenal glands [15]. The adrenal glands frequently have both primary and secondary tumors, and although DWI is expected to be useful in differentiation these tumors, the recent reports [16,17] showed limited usefulness of DWI, including ADC values in differential diagnosis.

80-year-old woman with normal adrenal glands DWI shows bilateral linear high signal intensity at the adrenal glands. K, kidney; S, spleen.
Benign Pathological Conditions
Hemorrhage

Thoracic hemorrhagic lesions with presence of oxyhemoglobin or extracellular methemoglobin may be hyperintense [18].
T2 shine-through effect

The signal intensity on DWI is based on water molecule diffusion and T2 relaxation time. Therefore, lesions with very long T2 relaxation times, such as cysts or fluid in the vessels, could still demonstrate high signal intensity even with high-diffusion sensitizing gradients (T2 shine-through effect). Mediastinal cystic lesions are usually benign; however, they could be hyperintense because of the T2 shine-through effect. ADC values may be helpful to avoid this risk.

37-year-old man with thymic cyst
A. Chest CT shows a well-defined oval structure beside the aortic arch.
B. DWI shows spotty high signal intensity of the lesion. The ADC value is relatively high ($1.72 \times 10^{-3}$ mm$^2$/s) suggesting the T2 shine-through effect.
Hemangioma

Spinal hemangiomas could be hyperintense on DWI. The reported ADC values of hepatic hemangioma are relatively high (1.92-2.29 x 10^{-3} \text{ mm/s}) \cite{19, 20}, but there are no reports on DWI of spinal hemangioma. To discriminate metastatic lesions, CT and PET findings should be considered.

30-year-old man with spinal hemangioma
A. Sagittal DWI shows high signal intensity at the mid thoracic spine.
B. Sagittal reformatted CT image shows coarse trabecula of the vertebral body in the mid thoracic spine.
Atheromas (subcutaneous epidermal inclusion cysts) are hyperintense on DWI, and, with their typical location, correct diagnoses can be easily made. The ADC values of subcutaneous atheromas are lower than those of intracranial inclusion cysts [21].

63-year-old man with atheroma
A. DWI shows a small hyperintense structure in the anterior chest wall.
B. CT shows a small atheroma in the subcutaneous tissue of the anterior chest wall.
Tuberculoma

Similar to brain abscesses, lung abscesses should demonstrate hyperintensity on DWI. DWI also shows bright signal intensity in tuberculomas [22] that can not be differentiated from lung cancer.

55-year-old woman with tuberculoma
A. CT shows an irregular nodule at the right apex.
B. DWI reveals a hyperintense nodule in the same region.
There are many pitfalls associated with the interpretation of chest DWI finding including those for both normal anatomical structures and pathological lesions. It is important for interpreters to be familiar with the appearance and physiological causes of pitfalls to avoid errors in diagnosis.
Selected articles


Our contact address:

Yasuyuki Kurihara, MD
Department of Radiology
St. Luke’s International Hospital
9-1 Akashi-cho, Chuo-ku, Tokyo, Japan 104-8560