

# **RADIOLOGY REVIEW FOR NEUROLOGISTS**

\*A.W.Olthof MD<sup>1</sup>, A.N.Zorgdrager MD<sup>2</sup>, R.R.Aliyev MD<sup>3</sup>

<sup>1</sup>*Radiology Department, Bethesda Hospital, Hoogeveen, the Netherlands,*

<sup>2</sup>*Neurology Department, Bethesda Hospital, Hoogeveen, the Netherlands,*

<sup>3</sup>*Neurology Department, Azerbaijan State Advanced Training Institute for Doctors named after A. Aliyev, Baku, Azerbaijan*

\*E-mail: olthof.a@bethesda.nl

## **Abstract**

Effective utilisation of imaging in neurology is facilitated by knowledge of technical background and a systematic approach in reading neuroradiological cases. The cooperation between neurologist and radiologist has the potential to improve neuroradiological patient care. In radiology pattern recognition plays an important role. Case reports are presented to help to recognise some common and uncommon pathology.

## **Introduction**

CT and MRI are commonly used examinations for neurological patients.

But what is an MRI examination? There are several ways to answer this question.

You can talk about technical details of the MRI machine. Or the imaging sequences commonly used. Or is the MRI examination also the report the radiologist produces?

There are different levels to look at medical technology [1, 2], including imaging [3]:

1. Technical efficacy is required to make images.
2. Diagnostic accuracy is the possibility to give a diagnosis based on the images.
3. The next level is whether the diagnostic test contributes to making a correct diagnosis.
4. After this level comes the question whether the results of imaging effects the treatment the patient receives.
5. Does the imaging test influence the patient's health outcome? That is the

next level.

6. At the level of society questions regarding cost-effectiveness from a societal perspective can be addressed.

These levels are used in technology assessment. Being aware of it helps to realize that knowledge of MRI or CT encompassing these issues can help you in using these imaging technologies. This paper will discuss the role of imaging in a clinical context and the role of the neurologist and the radiologist herein. Radiology is a discipline in which pattern recognition plays an important role. The second part of this paper consists therefore of several neuroradiology cases.

### **What the neurologist should know**

#### *Technical issues*

Neuroradiology is a rapidly evolving field. To evaluate whether techniques are useful or not [4], familiarity with the terminology is beneficial.

Also to be a good speaking partner for the radiologist, it is useful for the neurologist to have some basic knowledge of the imaging procedures they demand.

In depth technical knowledge is not required, in contrast to the MRI technician.

The neurologist should know what procedures can take place, and what the contra-indications are for these procedures.

The most important contra-indication for MRI is a pacemaker. With increasing numbers of pacemakers implanted in Azerbaijan [5], an increasing awareness is required for safe patient management. A reliable source for information about contra-indications and safety issues is found at internet [6]. Contra-indications for MRI can be divided in two categories. First conditions that influence the patient safety. Second conditions that influence the image quality. Metal components degrade the MRI image by distorting the magnetic field.

For CT the most important consideration is radiation dose. Especially in

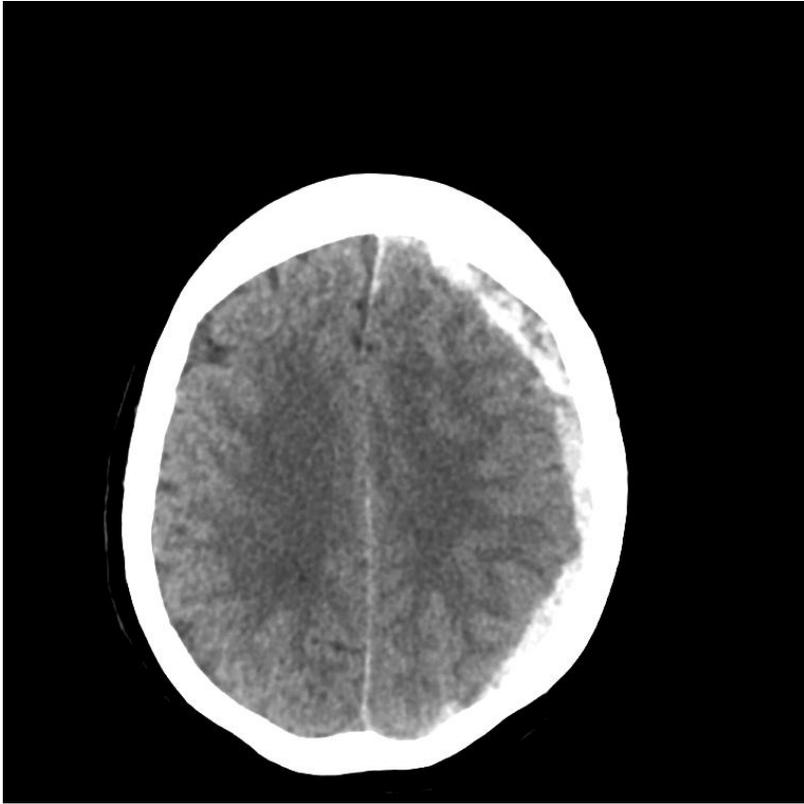
the younger age group this is a major issue. In the paediatric age group brain CT is much more requested compared to thoracic or abdominal CT. The frequency of paediatric CT differs per country. The highest frequency (or use) of CT in children, almost double that of Europe, was reported in Asia and in Africa [7]. It is advised to stay critical in using CT in infants because of radiation dose [8].

Both CT and MRI are black-white images. To interpret neuroradiological cases by himself, the neurologist should know the meaning of these shades of grey.

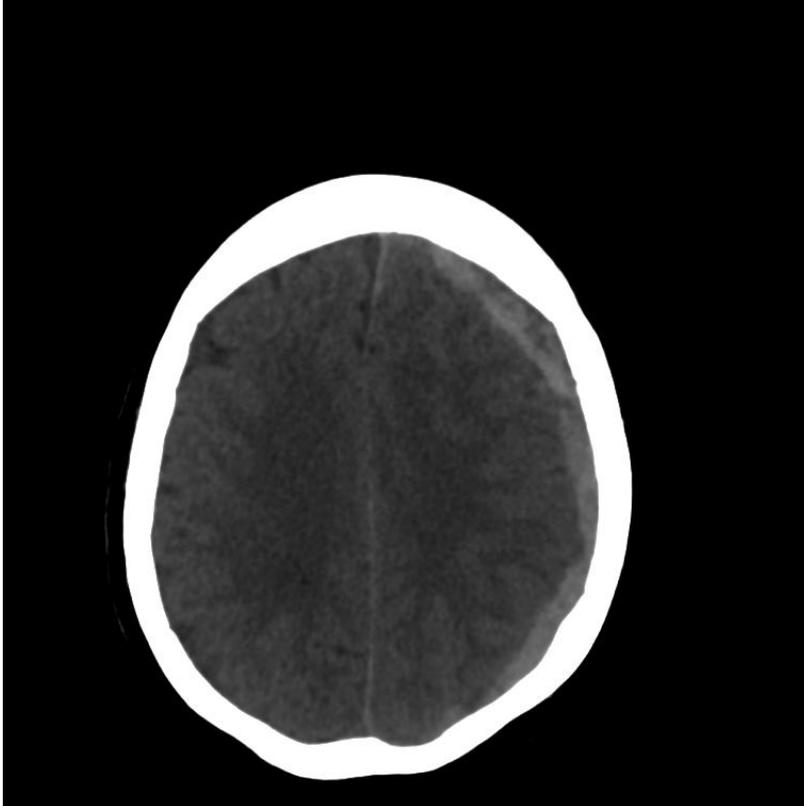
In CT white or light grey are described as high density. Black or dark grey are low density. The density values are expressed in Hounsfield Units. Each tissue has a particular density value. For example in increasing density: air (-1000 HU), lipid (-100 HU), water (0 HU), cerebrospinal fluid (15), soft tissue (50), acute haemorrhage (70), Calcification/bone (200 – 1000 HU).

Within this Hounsfield Unit scale, you can focus on particular densities. The two variables are the position you centre the grey-scale ('window level', WL), and the width of the grey-scale ('window width', WW). The optimal values to evaluate brain are WL=35, WW=70. The Subdural window (WL=70, WW=300) may show subdural fluid not seen in other windows. The bone window shows bone detail best (WL=600, WW=3000).

Figure 1 shows an illustration of the visibility of a subdural hematoma with different window width and window level settings.



a)



b)

**Figure 1. a) left-sided subdural hematoma, (WL=35, WW=70); both bone and subdural hematoma are white; b) left-sided subdural hematoma, (WL=70, WW=300). Subdural hematoma is grey, bone is white.**

In MRI the shades of grey depend on the sequence performed. The most commonly used sequences are T1 and T2. Each tissue has a different aspect on T1 and T2. White and light grey are 'high signal intensity'. Black and dark grey are 'low signal intensity'. Examples have shown in the Table 1.

**Table 1.**  
**Signal intensity of different tissues on T1 and T2 MRI sequences**

	T1	T2
Water	low	High
Fat	high	High
White/grey matter	intermediate	Intermediate
Haemorrhage	changes with time	changes with time
Edema	Low	High
Cortical bone, calcification	Low	Low
Bone marrow (depended on lipid content)	High	High

### *Consequences of imaging and setting the indication*

Before an imaging procedure is performed, the requesting clinicians should think about the consequences of imaging. Is the period until the scheduled appointment appropriate, or is there an indication for an urgent examination? Will the result of the imaging test narrow the differential diagnosis? Does the result of the procedure changes the therapeutic decisions? An insight in the sensitivity and specificity of diagnostic strategies helps to make a good selection of imaging [9].

### *Imaging request*

Besides the clinical information that is required on the imaging request,

information should be given to make it possible to perform the imaging in a safe manner.

Contra-indications for MR imaging should be asked the patient by the requesting physician in order to avoid unexpected events. Two questions can be asked concerning ferromagnetic materials in the patient. Can the imaging be performed safely? Or will the image quality deteriorate by the ferromagnetic material. When in doubt, the radiology department can be consulted. Internet can also give valuable information [6].

When ordering a brain CT for detection of tumor or metastases, intravenous contrast agent is required. Information about renal function is required on the request to decide whether the contrast agent can be applied safely or not [10]. Guidelines for using contrast media are available [11].

### **What the radiologist needs to know**

The imaging request starts with looking at the examination ordered. Is the requested examination appropriate to answer the question of the neurologist?

Information on the clinical history is required to give the radiologist understanding of the patient. Insight in the likelihood of pathology, as estimated by the neurologist, influences how the radiologist interprets the examination.

It is very useful to provide an accurate anatomic location of the expected pathology. This encompasses for example, in case of a lumbar spine MRI, to mention not only the side of the leg pain, but also which nerve root is possibly influenced.

The differential diagnosis helps to select the appropriate imaging protocol. The radiologist works together with radiology technicians and translates the medical information the neurologist provides to them, in order the most appropriate sequences can be performed.

### **Cooperation with the radiologist**

The neurologist exceeds the radiologist by far in clinical experience. The radiologist can learn to place the examination in a clinical context.

The radiologist is more experienced in the technical backgrounds of imaging. Knowledge of artefacts [12] is valuable to distinguish irrelevant findings from real pathology.

A good habit is to give each other feedback. The radiologist helps the neurologist by giving feedback when there are possibilities to improve the diagnostic strategy. When the neurologist gets more experienced in reading CT and MRI by himself, he can give feedback in case of discrepancy. Discrepancy in imaging findings can be reported by using the RadPeer terminology [13, 14]. Giving feedback improves accuracy.

A useful setting in which feedback can be given is a weekly or biweekly multidisciplinary clinical conference. The neurologist brings cases to discuss with the radiologist and other neurologists. Another reason to discuss imaging findings together is to use all relevant information when reading cases. Sometimes information can be provided, that was not available when the imaging was performed. Second reading can sometimes obviate new imaging, or alter the diagnostic strategy.

### **Case reading in Diagnostic Imaging**

It is important to train yourself in doing the reading process in a constant order. There are different strategies to do the reading process. It is attracting to start looking at the most obvious pathology at radiological images. In order to do a better performance, it is advisable to ask yourself some questions, before jumping to conclusions.

#### a. completeness

What is the examination date? Is the imaging indeed from your patient? Is the provided imaging complete? Is the report of the radiologist available?

#### b. technical issues and imaging protocol

What do you want to know? Is the technique appropriate to answer the question? Are the imaging sequences suitable to show this?

#### c. former examinations

Are there any former examinations performed and are they available? One of the first lessons a radiology resident learns is to use former examinations. A lesion visible on a prior CT 5 years before, will not be likely malignant.

d. recognising artefacts

What do you see? Is it an anatomical structure or an artefact? In MRI sometimes artefacts are obvious. Sometimes they are more subtle, and difficult to differentiate from real lesions.

e. systematic approach in case reading

All anatomic parts should be looked at. It is more important to do it every time the same way, than which order you choose. This systematic approach also helps to build a mental normal reference image in your mind, what facilitates detecting pathology. In Table 2 shown anatomic parts which should be looked at in MRI.

Table 2.

Systematic approach in brain and spine MRI

Brain MRI	Spine MRI
Brainstem	Position
cerebellum	shape of vertebral bodies
peripheral liquor spaces	bone marrow
ventricular system	vertebral discs, general and specific levels
basal ganglia	vertebral canal
white matter	neuroforamina
gray matter	facetjoints
hypophysis	paravertebral softtissues
cavernous sinus	other visible spaces (e.g. lungs, retroperitoneal space, pelvis)
orbit	
paranasal sinus	
skull	
extracranial soft tissues	

f. the corner of an examination; hiding place of pathology

Are there findings other than brain or spine related to the clinical findings? E.g. are the paranasal sinuses filled in a patient with headache?

g. are there relevant sidefindings

Is there e.g. a pulmonary lesion visible on a spine CT, which requires consultation of a pulmonologist? Is the aorta widened, which requires surgical consultation?

h. differential diagnosis

Are there diagnoses from the original differential diagnoses made unlikely by the imaging? Do the findings contribute to a definite diagnosis?

i. follow-up examination

When unanswered questions remain after the imaging is analysed, these problem solvers are useful.

- CT versus MRI. Supplemental to a CT examination MRI can give usually additional information. The other way around is sometimes the case.
- Contrast media. To get a higher accuracy an additional examination with contrast media can be performed. For CT iodinated contrast media is used and for MRI gadolinium. For detection of small brain metastases MRI with gadolinium is mandatory.
- Follow-up is a valuable tool in case of a lower probability of serious pathology.

### **Pitfalls**

Errors in diagnostic radiology can be divided in detection (perception) error and interpretation error.

In detection (perception) error the abnormality is overlooked. Causes are:

- insufficient training or expertise
- incomplete search of the image
- heavy workload / fatigue
- distractions (suboptimal viewing / interruption)

In interpretation (classification) error the abnormality is detected, but misinterpreted.

Drew et al. investigated inattentive blindness in radiologists. The

majority of them missed a gorilla while searching for long nodules. This indicates that even experienced searchers can miss unexpected events [15].

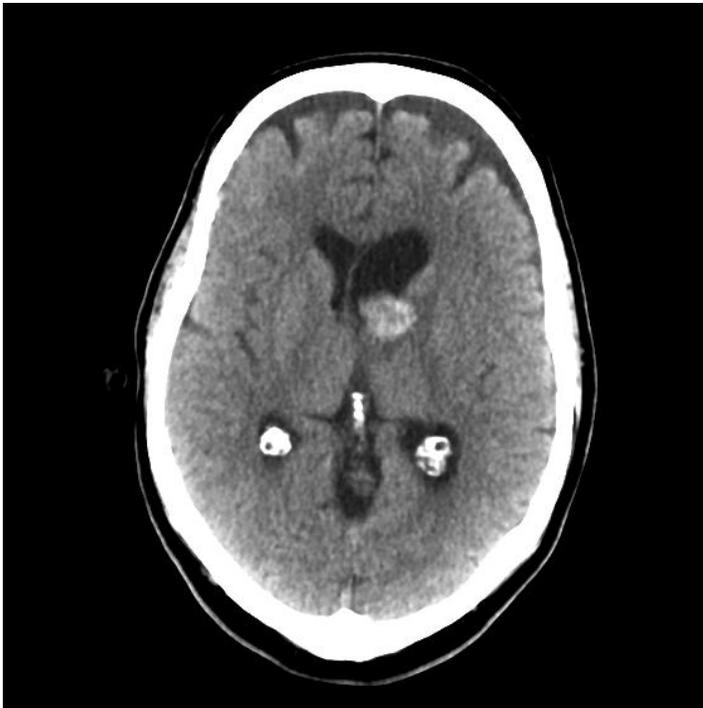
### **Case reports**

#### *Case 1*

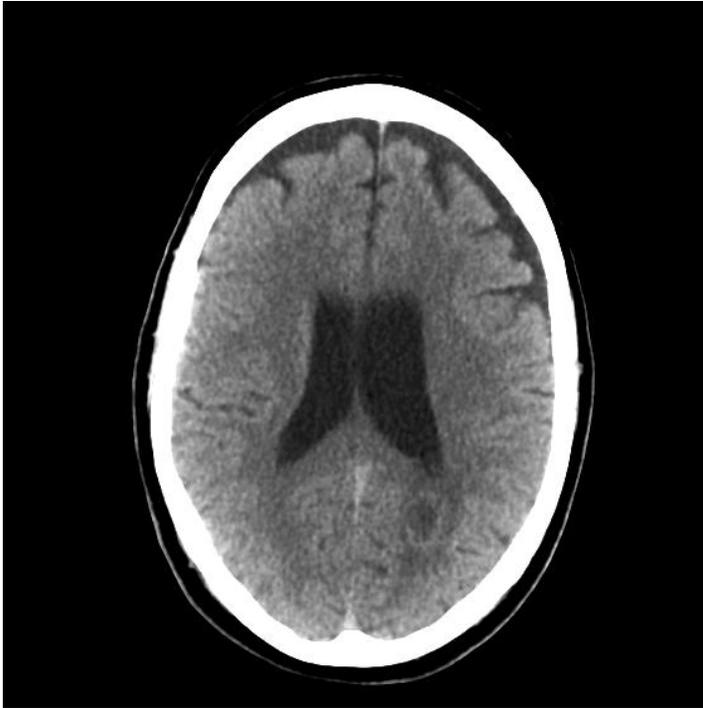
Male (70 years) since 7 months known to have non small cell lung cancer, treated with palliative chemotherapy. Now he presents with a slightly lowered consciousness.

Previous imaging: 3 months before presentation an MRI performed to exclude brain metastases was normal.

CT showed two hyperdens lesions. Differential diagnosis metastases or hemorrhage (Figure 2).



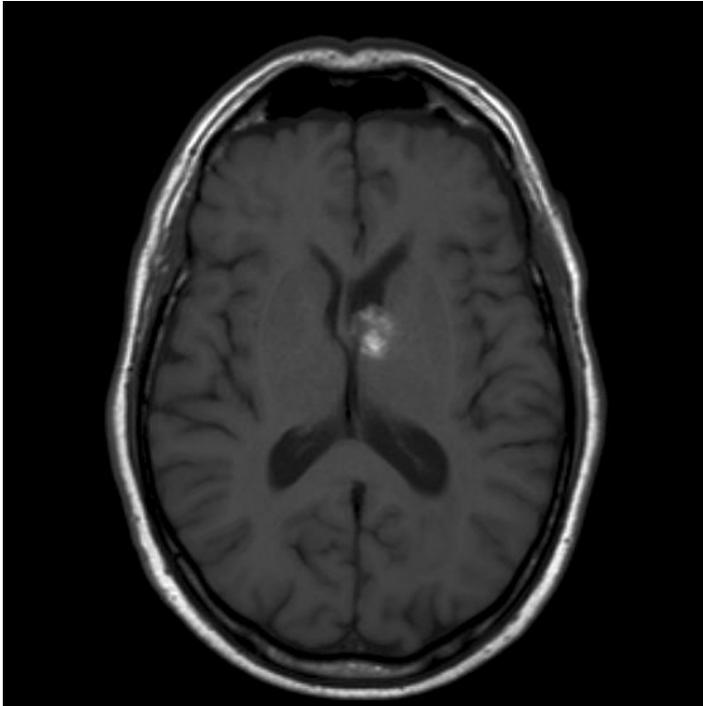
a)



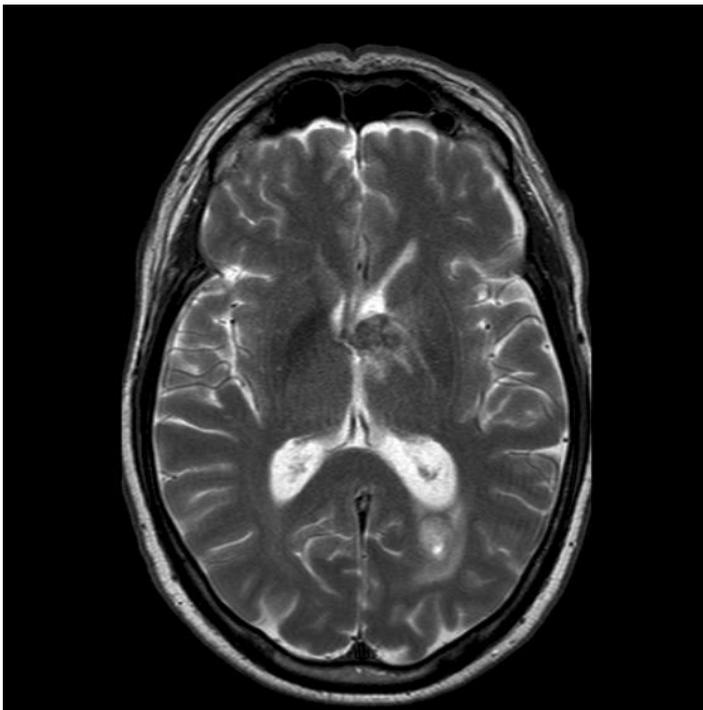
b)

**Figure 2. a) Native cerebral CT. Hyperdens lesion in the region of the caudate nucleus. b) Native cerebral CT. Isodens lesion with hyperdens rim left posterior.**

Two days later MRI was performed (Figure 3).



a)



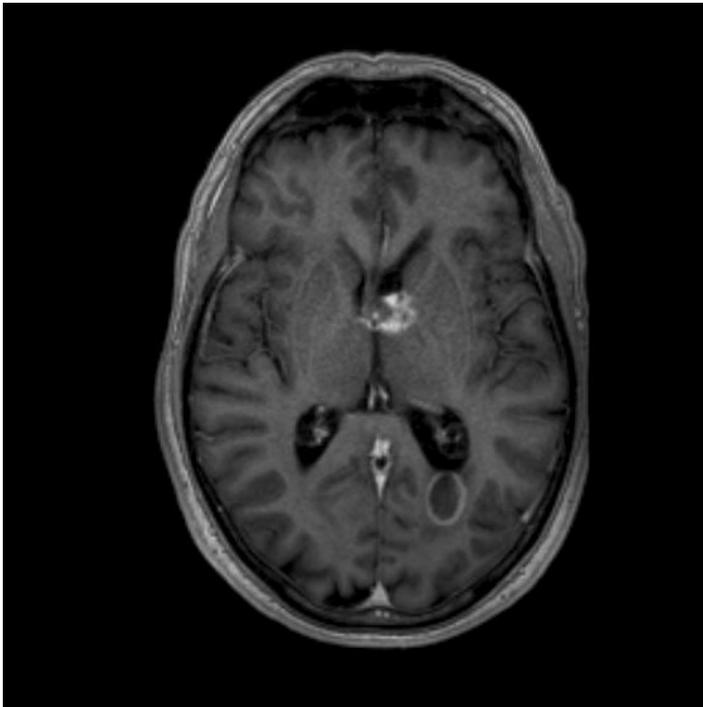
b)

**Figure 3. a) T1 weighted MRI. High signal intensity lesion near caudate nucleus, b) T2 weighted MRI.**

The lesion on the left side near the caudate nucleus has high signal intensity on the native T1 sequence and low signal intensity on T2. In this

setting that is compatible with hemorrhage.

The other lesions show rim enhancement (Figure 4), which is typical for metastases. Brain abscess can also show rim enhancement, but in this case that was ruled out by lacking high signal intensity on the diffusion weighted imaging. At T2 the lesions are surrounded by a high signal intensity zone: edema.



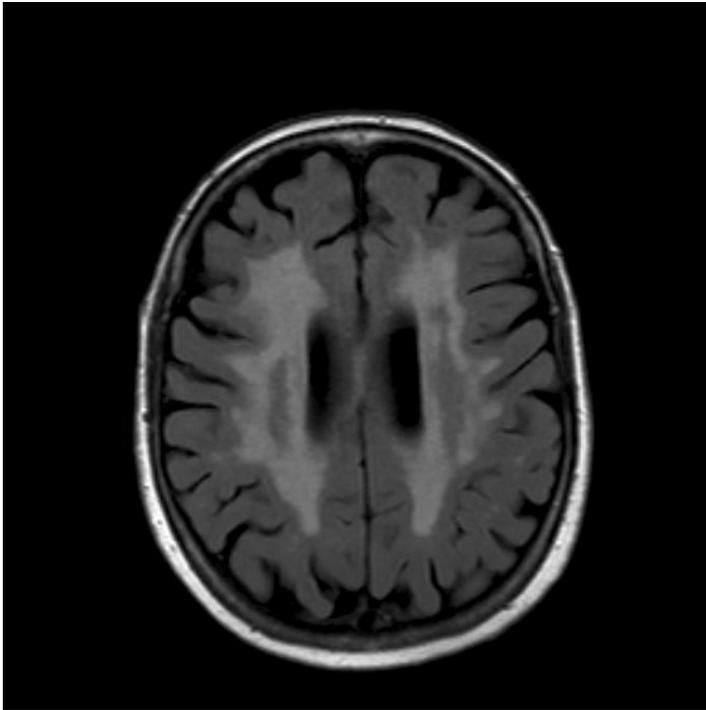
**Figure 4. Axial T1 after intravenous gadolinium administration.**

Diagnosis: Hemorrhagic cerebral metastases.

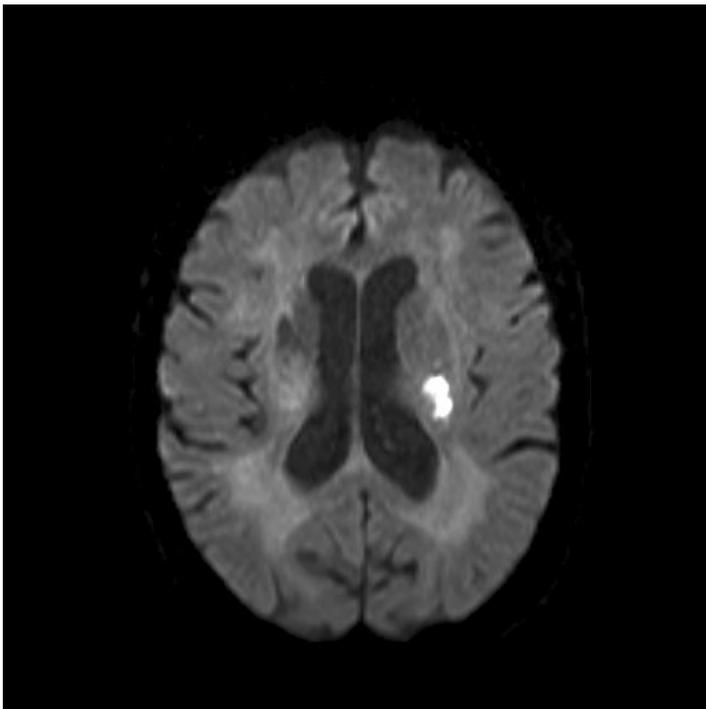
Patient was referred for palliative radiation therapy of the brain.

*Case 2*

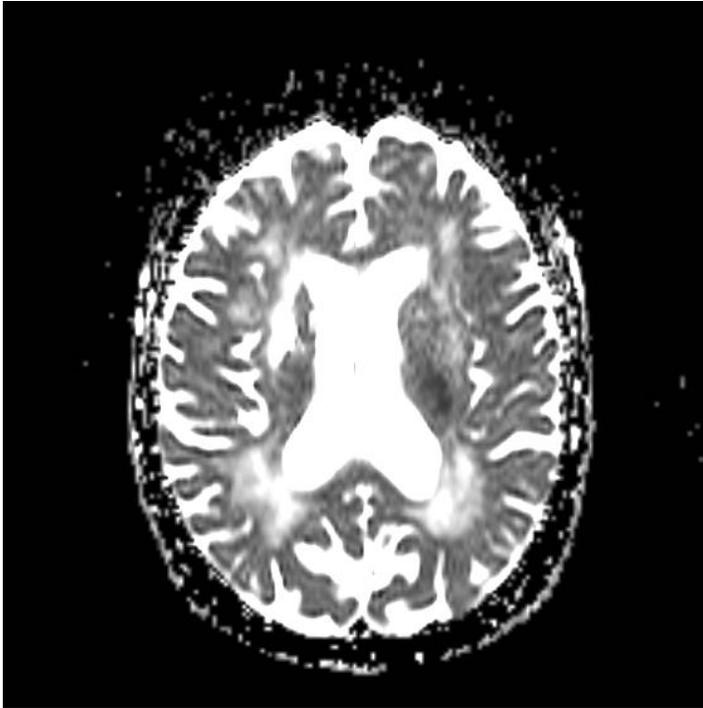
Female, 38 years. Since a few days slowly progressive right sided coordination disturbances. Imaging findings have shown in Figure 5.



a)



b)



c)

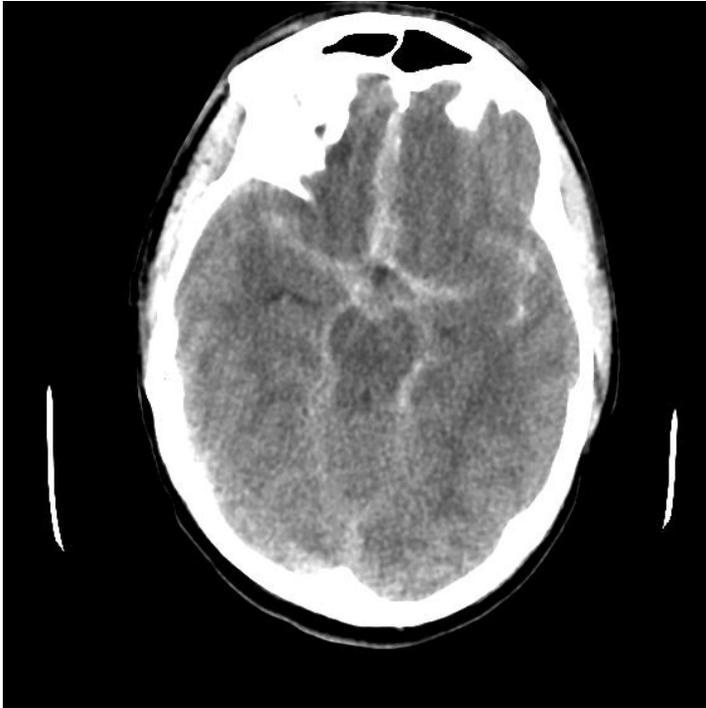
**Figure 5. a) FLAIR sequence, b) Diffusion weighted imaging, c) ADC.**

The FLAIR sequence shows extensive, confluent high signal areas depicted as white matter lesions of vascular origin. On diffusion weighted imaging a small high signal area left frontal in the centrum semiovale, with corresponding low signal at the ADC was found. This combination is typical ischemia of recent date [16].

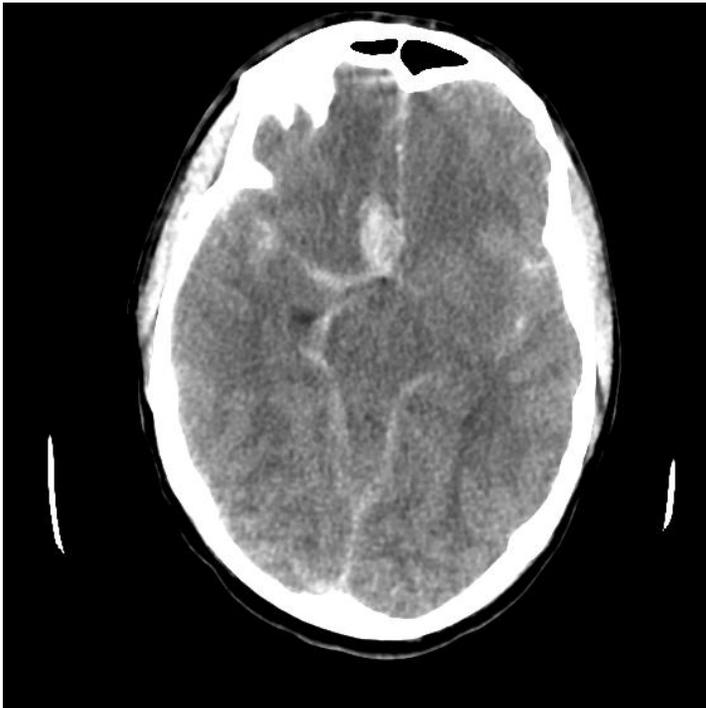
Diagnosis: Small ischemic cerebrovascular accident, extensive vascular white matter lesions. Patient continued on anticoagulant medication.

### *Case 3*

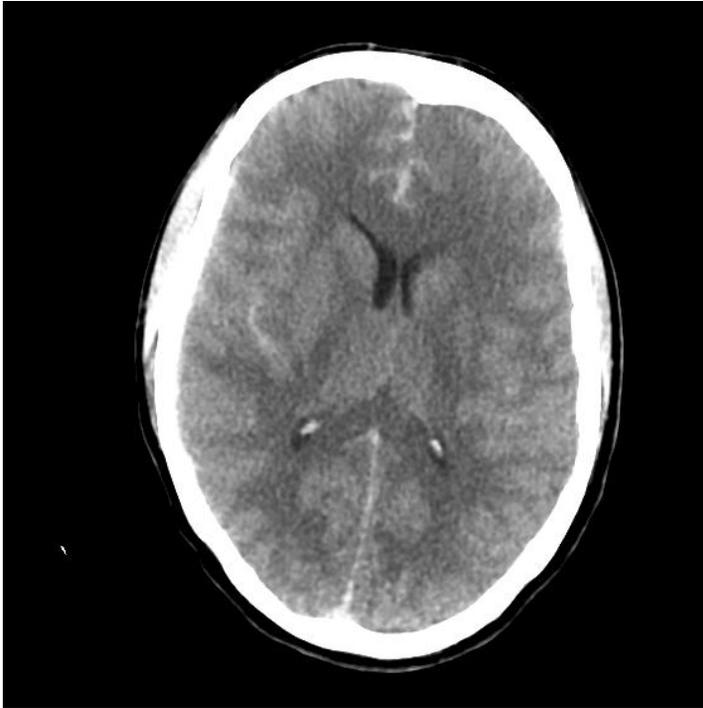
Female, 83 years, experienced sudden headache and lowered consciousness. Imaging findings have shown in Figure 6.



a)



b)



c)

**Figure 6. a, b, c) Native cerebral CT.**

CT shows a huge subarachnoid hemorrhage (Figure 6. a-c). Suggestion of intraparenchymal break through or a huge arteria communicans anterior aneurysm (Figure 6. b).

Diagnosis: subarachnoid hemorrhage.

Patient was transferred to the nearest University Hospital. CT angiography showed and ACOM aneurysm, which was treated by coiling.

#### *Case 4*

Male, 44 years.

Since 3 years gait disturbances, the last 6 months progressive.

Neurological examination showed diminished strength in the right leg and disturbed vital sensibility in the left leg.

Imaging findings.

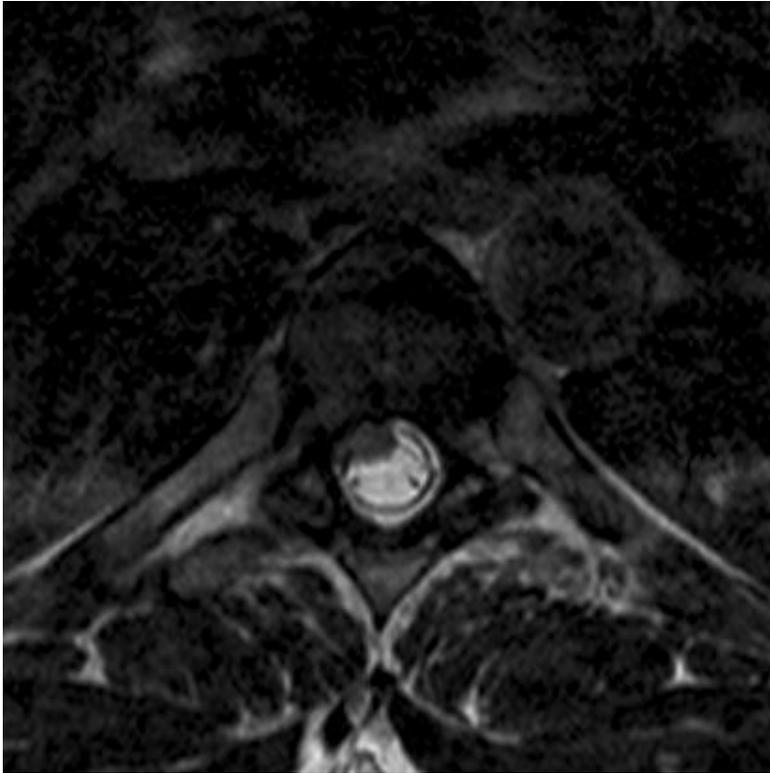
MRI of cervical, thoracic and lumbar spine was performed (Figure 7).



a)



b)



c)



d)

**Figure 7. a) Sagittal T1 weighted MRI, b) Sagittal T1 weighted MRI, c) Axial T2 weighted MRI, d) Sagittal T1 after intravenous gadolinium administration.**

At level Th5-6, the spinal cord is displaced to anterior (Figure 7 a-c). The sagittal plane shows the nodging of the spinal cord (Figure 7a-b). There was no abnormal high signal intensity of the spinal cord on T2 as is seen in myelopathy. No pathologic enhancement was found after contrast media administration (Figure 7 d).

Diagnosis: Anterior transdural spinal cord herniation. Patients was referred to the neurosurgery department. The neurosurgeon will perform an intradural exploration at level Th 5-6.

### **Conclusion**

Knowledge of each other's discipline and good cooperation and giving feedback improves patient care performed by neurologists and radiologist. Reading neuroradiological cases in a structural way improves accuracy.

### **References**

1. Littenberg B. Technology assessment in medicine. *Acad Med.* 1992 Jul;67(7):424-8
2. Thornbury JR, Eugene W, Caldwell Lecture. Clinical efficacy of diagnostic imaging: love it or leave it. *AJR Am J Roentgenol.* 1994 Jan;162(1):1-8.
3. Sunshine JH, Applegate KE. Technology assessment for radiologists. *Radiology.* 2004 Feb;230(2):309-14.
4. Barkhof F, Pouwels PJ, Wattjes MP. The Holy Grail in diagnostic neuroradiology: 3T or 3D? *Eur Radiol.* 2011 Mar;21(3):449-56.
5. Auricchio A, Kuck KH, Hatala R, Arribas F. European Heart Rhythm Association. EHRA White Book 2012.
6. MRISafety.com. <http://www.mrisafety.com/>
7. Vassileva J, Rehani M, Al-Dhuhli H et al. IAEA survey of pediatric CT practice in 40 countries in Asia, Europe, Latin America and Africa: part 1. Frequency and appropriateness. *AJR Am J Roentgenol.* 2012. 198:1021–1031.
8. Vassileva J, Rehani MM, Applegate K et al. IAEA survey of paediatric computed tomography practice in 40 countries in Asia, Europe, Latin America and Africa: procedures and protocols. *Eur Radiol.* 2013 Mar;23(3):623-31.
9. Pandor A, Goodacre S, Harnan S et al. Diagnostic management strategies for adults and children with minor head injury: a systematic review and an economic evaluation. *Health Technol Assess.* 2011 Aug;15(27):1-202.
10. Richenberg J. How to reduce nephropathy following contrast-enhanced CT: a lesson in policy implementation. *Clin Radiol.* 2012 Dec;67(12):1136-45.
11. European Society of Urogenital Radiology. <http://www.esur.org/guidelines/>
12. Morelli JN, Runge VM, Ai F, Attenberger U, Vu L, Schmeets SH, Nitz WR, Kirsch JE. An image-based approach to understanding the physics of MR artifacts. *Radiographics.* 2011

May-Jun;31(3):849-66.

13. Alkasab TK, Harvey HB, Gowda V, Thrall JH, Rosenthal DI, Gazelle GS. Consensus-oriented group peer review: a new process to review radiologist work output. J Am Coll Radiol. 2014 Feb;11(2):131-8

14. Jackson VP, Cushing T, Abujudeh HH, Borgstede JP, Chin KW, Grimes CK, Larson DB, Larson PA, Pyatt RS Jr, Thorwarth WT Jr. RADPEER scoring white paper. J Am Coll Radiol. 2009 Jan;6(1):21-5

15. Drew T, Vö ML, Wolfe JM. The invisible gorilla strikes again: sustained inattention blindness in expert observers. Psychol Sci. 2013 Sep;24(9):1848-53

16. Radiologyassistant.nl. 2008. <http://www.radiologyassistant.nl/en/p483910a4b6f14/brain-ischemia-imaging-in-acute-stroke.html>

## ОБЗОР ПО РАДИОЛОГИИ ДЛЯ НЕВРОЛОГОВ

<sup>1</sup>А.В.Олтхов, <sup>2</sup>А.Н. Зоргдрагер, <sup>3</sup>Р.Р. Алиев

<sup>1</sup>*Отделение радиологии, госпиталь Бетесда, Хогевен, Нидерланды,*

<sup>2</sup>*Отделение неврологии, госпиталь Бетесда, Хогевен, Нидерланды,*

<sup>3</sup>*Кафедра нервных болезней, Азербайджанский государственный институт усовершенствования врачей им. А.Алиева, Баку, Азербайджан*

**Эффективное использование радиологии в неврологии облегчается с техническими знаниями и системным подходом к чтению нейрорадиологических изображений. Сотрудничество неврологов с радиологами имеет потенциал для улучшения нейрорадиологического подхода к пациентам. В радиологии модель распознавания играет важную роль. Клинические случаи представлены, чтобы помочь распознать некоторые общие и редкие патологии.**

## NEVROLOQLAR ÜÇÜN RADIOLOGIYA ÜZRƏ İCMAL

A.W.Olthof MD<sup>1</sup>, A.N.Zorgdrager MD<sup>2</sup>, R.R.Əliyev MD<sup>3</sup>

<sup>1</sup>*Radilogiya Şöbəsi, Bethesda Hospitalı, Hoogeveen, Niderland krallığı,*

<sup>2</sup>*Nevrologiya Şöbəsi, Bethesda Hospitalı, Hoogeveen, Niderland krallığı,*

<sup>3</sup>*Sinir xəstəlikləri kafedrası, Ə.Əliyev ad. Azərbaycan dövlət həkimləri təkmilləşdirmə institute, Bakı, Azərbaycan*

**Effective utilisation of imaging in neurology is facilitated by knowledge of technical background and a systematic approach in reading neuroradiological cases. The cooperation between neurologist and radiologist has the potential to improve neuroradiological patient care. In radiology pattern recognition plays an important role. Case reports are presented to help to recognise some common and uncommon pathology.**