Atlas of CT Angiography

Normal and Pathologic Findings

Gratian Dragoslav Miclaus
Horia Ples

Second Edition

Springer

Atlas of CT Angiography

Gratian Dragoslav Miclaus • Horia Ples

Atlas of CT Angiography

Normal and Pathologic Findings

Second Edition

Springer

Gratian Dragoslav Miclaus
Department of Computer Tomography
SCM Neuromed
Timisoara
Romania

Horia Ples
Department of Neurosurgery
Victor Babeș University of Medicine
and Pharmacy
Timisoara
Romania

ISBN 978-3-030-16094-4 ISBN 978-3-030-16095-1 (eBook)
https://doi.org/10.1007/978-3-030-16095-1

This Springer imprint is published by the registered company Springer Nature Switzerland AG.
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

Permanent research in the field of medical radio-imaging concerning the non-invasive exploration of the circulatory system has led to the appearance and increasing use of the CT multislice for diagnostic purposes.

The acquisition by Neuromed Timisoara of the first computed tomography 64 multislice has placed Romania among the countries using state-of-the-art non-invasive technologies for diagnostic purposes. It is used not only for routine investigations but also in the diagnosis of cardiovascular pathology.

Worldwide, the existence and use of this technique avoids almost entirely the use of invasive methods for diagnostic purposes, which takes place only in exceptional circumstances. The invasive part of the diagnosis, which is extremely unpleasant to the patient, is thus eliminated from the diagnostic process, and patients now have the possibility of the diagnosis of vascular pathology without hospitalisation.

The technique is also beneficial to the doctors, as it enables them to identify and visualise the exact location of the damaged area, the anatomic details and the severity of lesions leading to a more appropriate planning of the operating techniques by the use of 3D reconstruction.

The present atlas aims to present some of the more challenging cases explored in our clinic during a period of 11 years. During this period, we explored more than 5000 CT coronary angiographies and more than 25,000 CT angiographies of other anatomic segments.

While the imagistic radiographs presented in this paper do not fully cover the vascular pathology, we consider it useful to present them in the hope that a great number of doctors will become familiar with the exploration possibilities given by this non-invasive method.

As was previously stated in the first edition, the present paper is subject to constant improvement, as our acquired experience and inventory of cases studied provide us with new and interesting insight. Therefore, we have added three new chapters and supplemented the first chapter with more cases.

The new added chapters are Cerebral Arteriovenous Malformations, Congenital Cardiac Malformations in Children and CT Phlebology.

Technical Principles

Computed tomography is a diagnostic technique which utilises X-rays, in which a small fascicle of X-rays axially traverses the patient's body from different angles. Parallel collimation is used to model the fascicle of rays into a small slot, which defines the width of the scanning plan. Detectors measure the intensity of the reduction of emerging radiation from the patient's body. A mathematical algorithm is used (inverse radon transformation) to calculate the reduction in each part of the CT section. These local reduction coefficients are then transformed into "CT numbers" and are finally converted into shades of grey which are then, in turn, shown as images.

Multislice tomographs allow the acquisition during a single rotation of the tube of a variable number of images (2-6-4), respectively, of a larger volume. The width of the slice is variable, with the spatial resolution growing in reverse proportion with the width. Therefore, for obtaining isotropy, the use of submillimetric widths is necessary. Isotopic acquisition allows us to reconstruct images in all three dimensions without modifying the spatial resolution. Thus, diagnostic accuracy in the case of isotopic acquisition is the same, indifferent of the spatial dimension in which the images are later reconstructed.

In the case of Somatom Sensation 64, the spatial resolution of an image is lower than 0.4 mm, and the acquired volume unit (voxel) has the same size for all three dimensions (under 0.4 mm for the x, y and z axes).

Obtaining such a resolution is possible due to the technical parameters offered by this machine and, particularly, the high rotation speed of the tube (330 ms) and the technical ability of the STRATON tube to generate two fascicles of X-rays which intertwine, generating the spatial resolution of 0.3 mm.

The length which may be scanned is also important; this machine permits the acquiring of images for a length of up to 1540 mm, which makes its use possible in peripheral angiographic studies.

All of these technical details, the high scanning speed and high temporal and spatial resolution, allow the use of the computed tomography in coronary angiographic studies, where the investigation of small arteries belonging to a continually moving organ is necessary.

The study does not aim to become a technical treaty or one of the CT exam protocols, but we consider it necessary to present a couple of technical possibilities for examination as well as a couple of advantages offered by the use of this type of computed tomography, in relation to the investigated area.

Cerebral CT Angiography

In our clinic, we use a scanning protocol which includes a native scan and a scan which follows the injection of intravenous contrast substance. We apply this protocol in order to obtain the subtraction of the bone, which allows the evaluation of the circulation in the cerebral arteries, without the presence of the bone structures of the neurocranium.

Following the bone subtraction, 3D MIP and 3D VRT reconstructions are used to visualise aneurysms as well as artery-vein malformations (AVM). Coming to the aid of neurosurgeons, we also use 3D VRT reconstructions without bone subtraction, which allows the planning of craniotomies in such a way that the remaining bone defect is at a minimum.

The method is also used to check post-operatory evolution in the case of applying metal clips or for selective arterial embolising procedures of the AVM.

Cerebral CT Arteriovenous Malformation

The method makes it possible to highlight the cerebral malformation, namely, measuring the nidus and displaying the associated feeder vessels and the drainage vessels. The design of the arteriovenous malformation at the brain level allows it to be included in the Spetzler-Martin scale. In this chapter, we exemplify all five types of Spetzler-Martin classification that are useful to the neurosurgeon, the endovascular neuroradiologist and the radiotherapist.

In this chapter, you can find comparative pre- and postoperative images. This shows the value of CT scanning in postoperative follow-up of the patient, as it is also a minimally invasive method versus Seldinger's angiography.

CT Angiography of the Cervical Region

This is used to visualise arterial circulation at the level of the cervical region as well as arterial pathology at this level. Thus, we are able to identify stenoses of the common carotid arteries, internal and external, of other arteries at the base of the neck and of vertebral arteries, as well as perform post-operatory or post-interventional checks at the level of the before-mentioned arteries. Thus, one can check the patency of carotid stenting, showing the presence or absence of restenosis in the stent.

Pre-operatory details regarding the parietal calcification at the level of the carotid arteries may be given.

As an examination protocol, we use 64 × 0.6 mm acquisition, with 1 mm reconstruction, and the optimisation of the presence of contrast in the carotid arteries is performed through bolus tests.

Post-processing consists of 3D MIP, 3D VRT and 3D MPR reconstructions.

Thoracoabdominal CT Angiography

This is used for visualising the pathology of the ascending aorta, of the aortic arch and the descending aorta, of the thoracic and abdominal portions and of the branches emerging from these, as well as for studying pulmonary arteries for pulmonary thromboembolism or for malformative pathology.

As a scanning protocol, we use 64 × 0.6 mm scanning, with a variable rotation of the tube, according to the pathology, with 1 mm reconstructions; in order to find SDC presence in the arterial circulation, we use bolus tests.

Peripheral CT Angiography

This is used for discerning arterial pathology at the level of the lower and upper limbs. It shows the presence of arterial stenoses in obliterating arteriopathy and allows the evaluation of the venous or synthetic graphs used in bypass interventions, as well as the evaluation of the patency of the stents placed at different levels.

It may identify arteriovenous fistulas as well as malformative lesions at the level of the limbs' circulatory bed.

CT Coronary Angiography

CT coronary angiography currently represents one of the most important non-invasive diagnostic possibilities offered by computed tomography.

In our clinic, over the course of 1 year, over 500 patients were investigated with the purpose of detecting coronary affections, as well as patients with stents and aorto-coronary bypasses with the purpose of determining their patency.

In our CT coronary angiography examining protocol, we use native scanning in order to detect and quantify coronary calcifications (Agatston calcium score), followed, if the calcifications are not severe, by the proper angiographic phase. Optimisation of the presence of the contrast substance at the coronary level is done through bolus tests, with the quantity of contrast substance administered depending on the scanned surface. In order to reduce the dose administered to the patient, we use CARE Dose 4D and modulated ECG acquisition with pulsed ECG.

The images are acquired in the format 64 × 0.6 mm, with the reconstruction of axial images at 0.75 mm. Post-processing consists of 3D VRT, 3D MPR and 3D MIP reconstructions. The software of the post-processing unit allows the quantification of the degree of stenosis, expressing the result either as an area or percentage.

Congenital Cardiac Malformations in Children

Paediatric cardiac pathology, especially congenital malformative one, represents, through its complexity and, sometimes, dramatic character of its symptomatology, a challenge for the clinician as well as for the radiologist.

Throughout my 12 years of activity in our clinic, I have explored around 400 cases of children with congenital cardiac malformations.

As an exploration protocol, I have used scanning without ECG synchronisation, with administration of contrast, under IV (intravenous) anaesthesia, limiting the duration and exposure to ionising radiation and the length of the scanned area in order to obtain high-quality diagnostic images.

The details given by 3D and 3D VRT reconstructions allowed us to specify with great precision the present anatomical modifications and offered a wider field of view that the cardiovascular surgeon can benefit from when planning the operation.

CT Phlebology

When exploring the venous system and its pathology, besides Doppler echography, which is the main method of examination, CT phlebography and especially phlebography with anterograde contrast injection can occupy a highly important role in establishing the diagnostic and therapeutic conduit.

In our clinic, we have explored about 280 cases using this technique, improving our contrast injection protocol in order to obtain the best opacification of the profound venous system and, implicitly, answer the questions addressed by the physician.

The fact that it is possible to view the permeability of the profound veins and perforators, the presence of thrombus as well as anatomical variants and the causes of chronic venous deficiency makes this method a very useful tool that should be taken into consideration when completely evaluating a patient presented with venous pathology of the inferior limbs.

Timisoara, Romania Gratian Dragoslav Miclaus

Contents

Cerebral Angiography

1

Contents

G. D. Miclaus, H. Ples, *Atlas of CT Angiography*, https://doi.org/10.1007/978-3-030-16095-1_1

1.1 Normal Cerebral Angiography

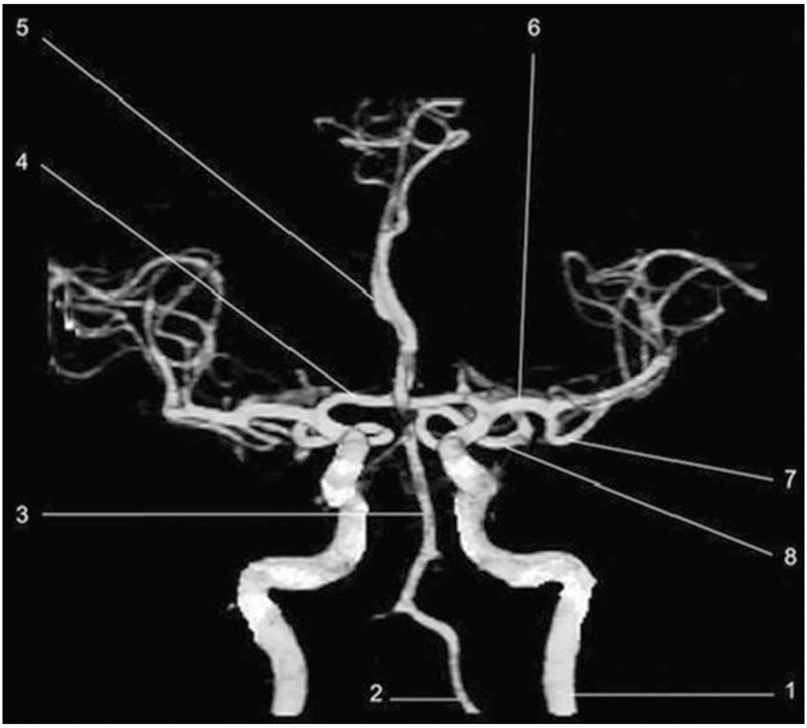

Fig. 1.1 Neuro DSA—VRT
1. A. carotis interna
2. A. vertebralis
3. A. basilaris
4. A. cerebri anterior
5. A. cerebri anterior—segmentum A2
6. A. cerebri media—segmentum M1
7. A. cerebri media—segmentum M2
8. A. cerebri posterior

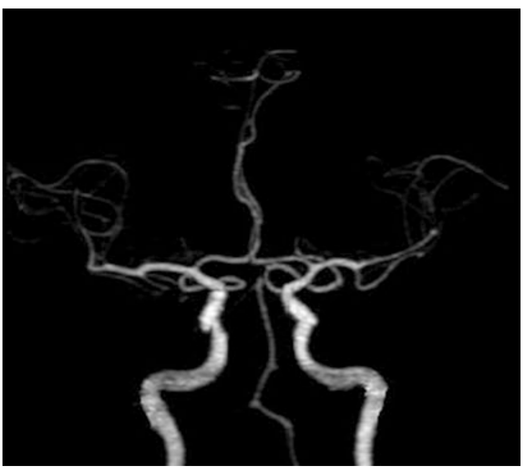

Fig. 1.2 Neuro DSA—MIP

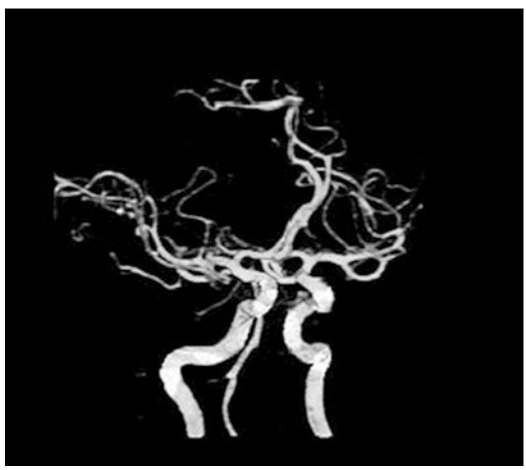

Fig. 1.3 Neuro DSA—VRT

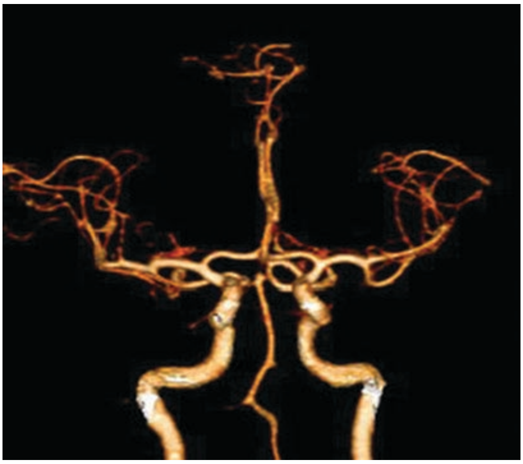

Fig. 1.4 Neuro DSA—VRT colour

Fig. 1.5 Neuro DSA—VRT colour

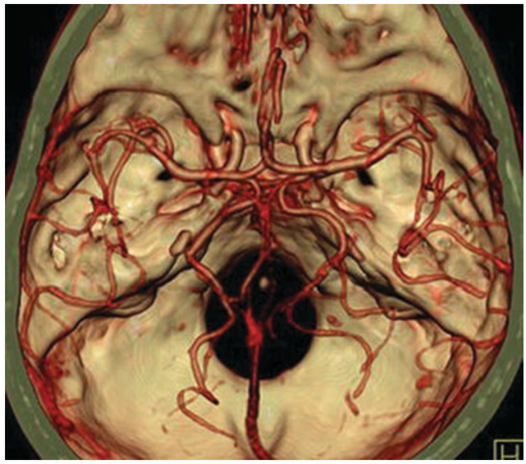

Fig. 1.6 Cerebral angiography 3D VRT reconstruction

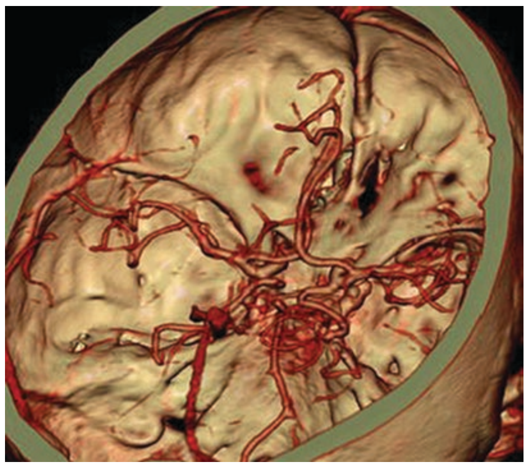

Fig. 1.7 Cerebral angiography 3D VRT reconstruction

1.2 Arteria Basilaris Aneurysm at the Level of Pars Proximalis

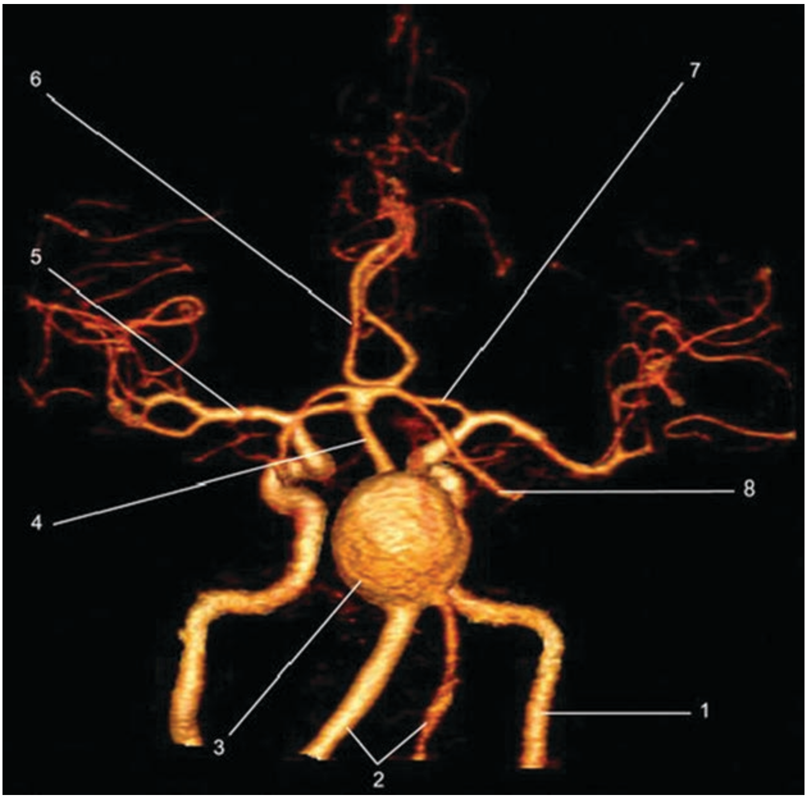

Fig. 1.8 Neuro DSA 3D VRT colour reconstruction

1. A. carotis interna
2. A. vertebralis
3. Giant aneurysm
4. A. basilaris
5. A. cerebri media—segmentum M1
6. A. cerebri anterior—segmentum A2
7. A. cerebri anterior—segmentum A1
8. A. cerebri posterior

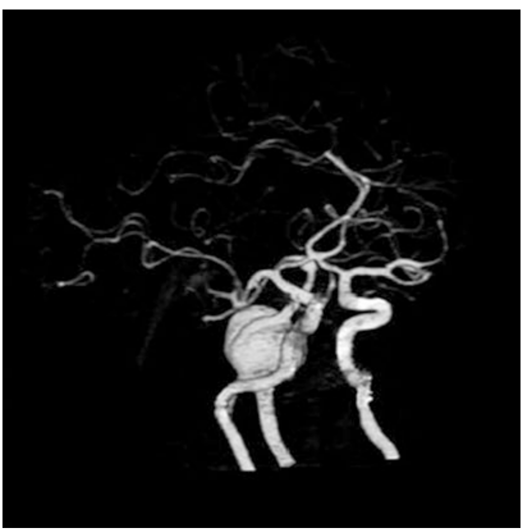

Fig. 1.9 Neuro DSA 3D MIP reconstruction

Fig. 1.10 Neuro DSA 3D MIP reconstruction

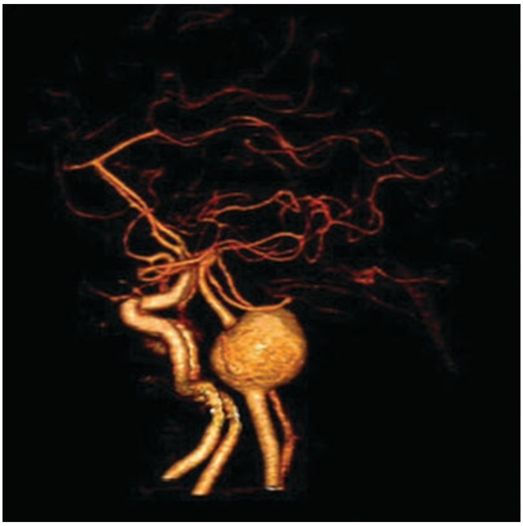

Fig. 1.11 Neuro DSA 3D VRT colour reconstruction

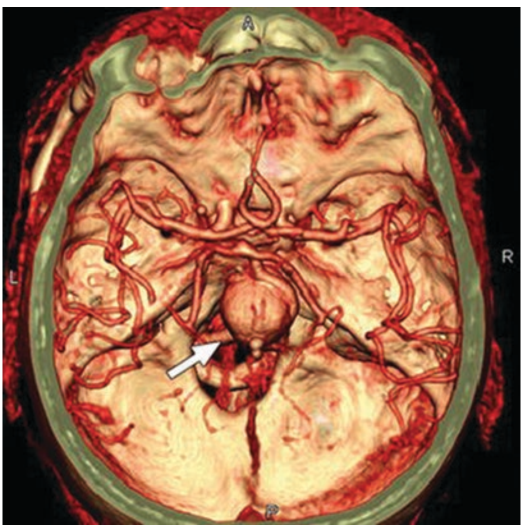

Fig. 1.12 Cerebral angiography axial 3D VRT reconstruction. The *arrow* indicates the aneurysm

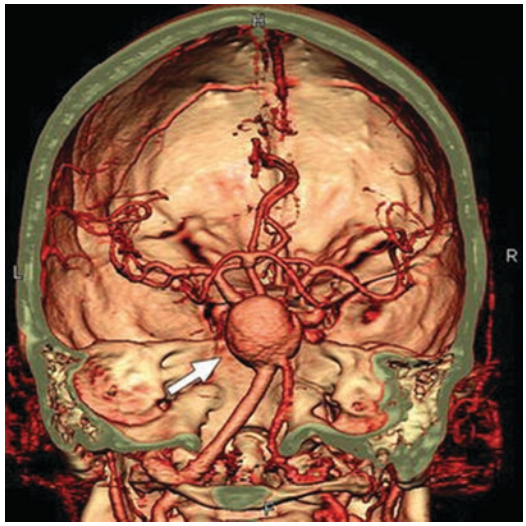

Fig. 1.13 Cerebral angiography 3D VRT reconstruction in posterior coronal plan. The *arrow* indicates the aneurysm

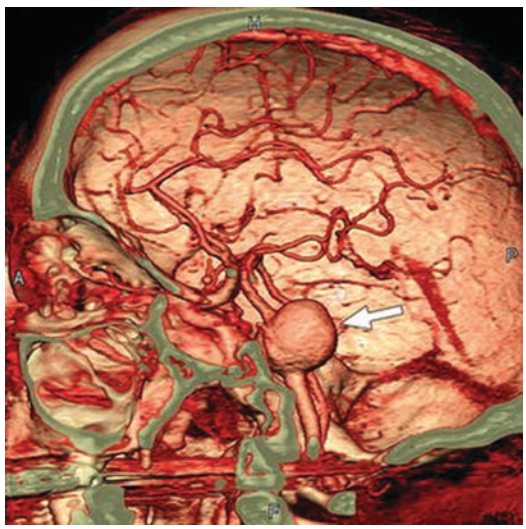

Fig. 1.14 Cerebral angiography 3D VRT reconstruction, sagittal plane. The *arrow* indicates the aneurysm