Original Research Paper

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Radiology

EVALUATE EFFICACY OF ENDOVASCULAR MANAGEMENT OF INTRA-CRANIAL ARTERIO-VENOUS MALFORMATION

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ABSTRACT

AIM - to evaluate the efficacy of endovascular management of intra-cranial arterio-venous malformation

OBJECTIVES –

- To evaluate the technical efficacy of endovascular management of intra-cranial arterio-venous malformation
- To study the outcome of patients with intra-cranial AVM, treated by endovascular embolization.

METHODOLOGY - This was Prospective study carried out at database of all neurointerventional cases performed by the interventional neurology team at AVBRH, Wardha, Maharashtra, India in 6 Months period i.e. April 2018 to September 18 were included for the study. A sample size of 25 was taken. Onyx® was used for embolization in all the cases.

RESULT: In our study the majority of the patients were in the age group of 30-40 were 36%,20-30- 24%, < 20-20%, 40-50- 21%, 50-60 and >60 were 4% each. Males- 68%,Females-32%.Most common symptom was Headache in 76%,Vertigo- 68%,Seizure- 44%,Tinnitus- 36%,Blurred image- 32%, Difficulty in speaking-20% and Photophobia-12%. GCS scoring 9-12=48%, 12-15=28%, 6-9=16%, 3-6=8%. Hess and Hunt classification grading 3-44%,Grade 2-24% patients, grade 1-16% patients. Grade 4 & 5-8% patients each. Spetzler Martin grading scale, grade 4-36%. Grade 3-28%, grade 5-20%. Grade 2-12% patients and Grade 6-4% patients. Medium sized Cerebral AVMs-40% patients. Large AVMs-32% patients. 20% patients-small AVMs. Giant AVMs- 8% patients. Majority (40%) of Cerebral AVMs were located in the dominant cerebral hemisphere. 32%-non dominant cerebral hemisphere.12%-basal ganglia. 5 patients were referred for radiosurgery (20%).

KEYWORDS :

INTRODUCTION –

Various causes of subarachnoid haemorrhage are trauma (with associated cerebral contusion): traumatic subarachnoid haemorrhage and spontaneous subarachnoid haemorrhage caused by ruptured berry aneurysm, perimesencephalic haemorrhage,arteriovenous malformation (AVM), dural arteriovenous fistula (DAVF), spinal arteriovenous malformation, venous infarction, intradural arterial dissection.

Arteriovenous malformations (AVMs) of the brain are vascular lesions that are complex and rare and are a cause of significant morbidity and mortality. They are congenital anomalies consisting of nidus of blood vessles through which arteriovenous shunting occurs. There is lack of a true capillary bed. They develop over time and usually present before the age of 20 years. Mean age of presentation of 30-40 years. There is no gender predilection.

Our study included Brain AVM/ Pial AVM and proliferative type brain AVMs. AVMs are treated with a multimodality approach with endovascular embolization done primarily as a preoperative adjuvant before microsurgery or radiosurgery.

Clinically, patients with intra-cranial AVM's present with intracranial hemorrhage, headaches, seizures and long-term disability; hemorrhage and seizures being the most common complaints.

Brain AVMs can be divided into two types -

- Compact (or glomerular) nidus: abnormal vessels without any interposed normal brain tissue
- Diffuse (or proliferative) nidus: no well-formed nidus is present, with functional neuronal tissue interspersed amongst the anomalous vessels.

Cerebral angiography is the gold standard for diagnosis of cerebral AVM. My study was done to provide, after a comprehensive literature review, the benefits and risks of multiple management options available for treating cerebral Aneurysms and AVM for eg. conservative medical methods, microsurgical resection and endovascular embolization, giving endovascular embolization prior importance. Also, I studied and compared the clinical presentation of all patients with Cerebral AVM and its relation to the preferred management options.

The outcome of patients treated with Cerebral AVM was also be studied by me.

MATERIALS AND METHODS -

TYPE OF STUDY – Prospective study
DURATION OF STUDY – 6 Months
SAMPLE SIZE - 25

INCLUSION CRITERIA –

- Ages Eligible for Study: All ages (Adult, Older Adult)
- Sexes Eligible for Study: All
- Accepts Healthy Volunteers: No
- Sampling Method: Non-Probability Sample
- Patients having a brain arteriovenous malformation

EXCLUSION CRITEA –

- Patients protected by law
- Poor surgical candidate

The data was prospectively collected from the database of all neurointerventional cases performed by the interventional neurology team at AVBRH, Sawangi, Wardha. Demographic information: age, sex and ethinicity was collected. The clinical characteristics of all the patients with Cerebral Arterio-venous malformation was graded using the Hunt and Hess grading scale, Fisher grade, and Glasgow coma scale (GCS).

The various scale's used for grading are depicted below.

Prior to taking the patient for endovascular embolization, the patient was graded using these scales.

World Federation of Neurological Surgeons Scale (15)

Glasgow Coma Scale

	1	2	3	4	5	6
Eyes	Does not open eyes	Opens eyes in response to painful stimuli	Opens eyes in response to voice	Opens eyes spontaneously	N/A	N/A
Verbal	Makes no sounds	Incomprehensible sounds	Utters inappropriate words	Confused, disoriented	Oriented, converses normally	N/A
Motor	Makes no movements	Extension to painful stimuli	Abnormal flexion to painful stimuli	Flexion / Withdrawal to painful stimuli	Localizes painful stimuli	Obeys commands

Hunt and Hess Classification (16)

Grade 1	Asymptomatic or minimal headache with slight nuchal rigidity
Grade 2	Moderate to severe headache, nuchal rigidity, noneurologic deficit other than cranial nerve palsy
Grade 3	Drowsiness, confusion, or mild focal deficit
Grade 4	Stupor, moderate to severe hemiparesis, possibly early decerebrate rigidity, and vegetative disturbances
Grade 5	Deep coma, decerebrate rigidity, moribund appearance

Also, prior to taking patient for embolization, cerebral avms were categorized by **spetzler martin grading scale**.
Size of AVM
Small (<3 cm) 1
Medium (3-6 cm) 2
Large (>6 cm) 3
Location
Noneloquent site 0
Eloquent site* 1
Venouse drainage
Superficial 0
Deep 1

*Sensorimotor, language, visual cortex, hypothalamus, thalamus, brain stem, cerebellar nuclei, or regions directly adjacent to these structures.

The Spetzler Martin Grading Scale estimates the risk of open neurosurgery for a patient with AVM, by evaluating AVM size, pattern of venous drainage, and eloquence of brain location. A Grade 1 AVM would be considered as small, superficial, and located in non-eloquent brain, and low risk for surgery. Grade 4 or 5 AVM are large, deep, and adjacent to eloquent brain. Grade 6 AVM is considered not operable. However, that this scale does not necessarily correlate with risk of treatment by embolization.

The features of the procedure like date of the procedure, aneurysm size, location and morphology, total radiation exposure, and endovascular devices were collected. The embolization using Onyx was performed on Philips Alura X Per FD 20 machine.

The following features of all AVMs were evaluated before the treatment: type of nidus and shunt, draining veins, and feeding arteries. Operative complications, both intraprocedural and periprocedural (48h) were studied if present and classified into major and minor types. The various complications were categorized as follows:

a) procedural complications – thromboembolic events, rupture/perforation etc.
b) disability at 1 month, studied by the modified Rankin scale (score >2).

The modified rankin scale, shown below, was used to grade the outcome of the treatment of patients with intracranial AVM. The patients were called for follow up after 1 month and clinically graded using this scale, thus helping us document the outcome of endovascular embolization.

Modified Rankin Scale (18)

Level	Description
0	No symptoms
1	No significant disability, despite symptoms; able to perform all usual duties and activities
2	Slight disability; unable to perform all previous activities but able to look after own affairs without assistance
3	Moderate disability; requires some help, but able to walk without assistance
4	Moderately severe disability; unable to walk without assistance and unable to attend to own bodily needs without assistance
5	Severe disability; bedridden, incontinent, and requires constant nursing care and attention
6	Dead

The statistical analysis was done by SPSS 19 version software.

RESULTS –

Table I: Distribution of the patients as per the age

Age	No.	Percentage (%)
< 20	5	20
20-30	6	24
30-40	9	36
40-50	3	12
50-60	1	4
>60	1	4

The majority of the patients were in the age group of 30-40 were 36% followed by 20-30 which were 24%, < 20 were 20%, 40-50 were 21%, 50-60 and >60 were 4% each.

Table II: Distribution of the patients as per the sex

Sex	No.	Percentage (%)
Male	17	68
Female	8	32
Total	25	100

The majority of the patients were Male i.e. 68% followed by Female 32%.

Table III: Distribution of the patients as per the symptoms

Symptoms	No.	Percentage (%)
Headache	19	76
Vertigo	17	68
Seizure	11	44
Tinnitus	9	36
Blurred image	8	32
Difficulty in speaking	5	20
Photophobia	3	12

(* More than one symptoms present in the patients)

The most common symptoms were Headache in 76% followed by, Vertigo in 68%, Seizure In 44%, Tinnitus in 36%, Blurred image in 32%, Difficulty in speaking in 20% and Photophobia in 12%.

Table IV: Distribution of the patients as per the GCS

GCS	No.	Percentage (%)
3-6	2	8
6-9	4	16
9-12	12	48
12-15	7	28

The majority of the patients were having the GCS in 9-12 were 48%, followed by 12-15 were 28%, 6-9 were 16%, 3-6 were 8%.

Table V: Distribution of the patients as per the Hunt and Hess Classification

Grade	No.	Percentage (%)
1	4	16
2	6	24
3	11	44
4	2	8
5	2	8

The majority of patients had Hess and Hunt classification grading 3 (44%). Grade 2 was seen in 24% patients followed by grade 1 which was seen in 16% patients. Grade 4 and 5 were seen in 8% patients each.

Table VI: Distribution of the patients as per the Spetzler Martin grading scale

Grade	No.	Percentage (%)
1	0	0
2	3	12
3	7	28
4	9	36
5	5	20
6	1	4

The majority of patients had Spetzler Martin grading scale as grading 4 (36%). Grade 3 was seen in 28% patients followed by grade 5 which was seen in 20% patients. Grade 2 was seen in 12% patients and Grade

6 were seen in 4% patients.

Table VII: Distribution of the patients as per the AVM size

Size	No.	Percentage (%)
Small (<3cm)	5	20
Medium (3-6cm)	10	40
Large (>6cm)	8	32
Giant	2	8

Medium sized Cerebral AVMs were seen in 40% patients. Large AVMs were seen in 32% patients. 20% patients had small AVMs. Giant AVMs were seen in only 8% patients.

Table VIII: AVM Topography

Location	No.	Percentage (%)
Cortical/ Subcortical · **Dominant** · **Non-Dominant**	10 8	40 32
Cerebellum	1	4
Basal Ganglia	3	12
Corpus Callosum	1	4
Thalamus	2	8

Majority (40%) of Cerebral AVMs were located in the dominant cerebral hemisphere. 32% were located in the non dominant cerebral hemisphere. 12% Cerebral AVMs were noted in basal ganglia.

Superselective angiography of AVM feeders was performed prior to every embolization procedure using 6 frames per second. The feeding arteries and the early draning veins were identified. The embolization was done using Onyx, as close to the nidus of AVM as possible.

Systemic heparinization was utilized in all patients by bolus intravenous injection of 3000 units of heparin followed by an i/v bolus of 1000 units per hour. Systemic heparinization was reversed after the procedure with i/v injection of 10 mg of Protamine Sulfate per 1000 units of Heparin. All patients were admitted to Neuro-ICU for 12 hours and then, if indicated, transferred to the Medicine ward.

All patients were subjected to post embolization non-contrast head CT scan to depict any complication for eg. Intra-cranial bleed, subarachnoid, parechymal or intra-ventricular in nature due to perforation of a small artery or an incompletely embolized nidus.

The transfemoral, transarterial route was used in all patients (100%). Microcatheters were used for superselective angiography of feeders of AVM.

Procedural complications were seen in 2 out of 25 patients (8%). 1 patient had intraventricular haemorrhage with hydrocephalous post embolization. VP shunting was a day after OT.

Table IX: Distribution of the patients as per the cure per session of the embolization

Sessions		Cure			Total
		Yes	No	Lost	
I	No.	13	7	0	20 (80%)
	%	52	28	0	
II	No.	4	1	0	5 (20%)
	%	16	4	0	

8 patients were referred for radiosurgery (32%). Thus, 17 patients were cured in either 1 or 2 settings (68%).

All patients were called after 1 month for follow up and clinically grade using modified rankin scale. Postembolization clinical complications were classified as *mild* (patient could return to his/her personal and professional functional life), *moderate* (able to be independent at home but incapable to return to previous working capacity) and severe (patient lost personal functional independence and incapable of working).

Table X: Postembolization Clinical Complications

Classification	No.	Percentage (%)
Mild	11	44
Moderate	10	40
Severe	4	16

Table XI: Distribution of the patients as per the Modified Rankin Scale

Level	No.	Percentage (%)
0	7	28
1	6	24
2	6	24
3	2	8
4	3	12
5	1	4
6	0	0

We did not achieved successful embolization in most large or giant AVMs presenting with progressive neurological deterioration.

DISCUSSION -

The most frequent vascular malformations of the brain, and the most significant because of the concomitant risk of bleeding, are cerebral arteriovenous malformations and dural arteriovenous fistulas. The former are lesions in which a nest of vessels creates pathological communications between arteries and veins, without an intervening capillary bed. They are probably the result of a congenital abnormality of blood vessels emerging in fetal life; however, they may be associated with hereditary syndromes – including Rendu-Osler-Weber disease (hereditary hemorrhagic telangiectasia) and Wyburn-Mason syndrome.

Their incidence and prevalence are unknown, although there are data derived from autopsy series or limited population studies in different published series, with figures ranging between 0.8 and 2.1 cases for every 100,000 inhabitants. Several classifications have been developed, but the most widely used is the Spetzler-Martin classification that defines the risk associated with the surgical treatment and provides uniformity to the different reports. It classifies arteriovenous malformations on the basis of their size, location and venous drainage ([8-11]).

When arteriovenous malformations are symptomatic, they gives rise to different clinical manifestations such as headache, seizures or neurological decline secondary to cerebral hemorrhage, and they are more frequent among young adults between the third and fourth decades of life.

Treatment of cerebral arteriovenous malformations includes endovascular management, stereotactic radiosurgery, surgery, or conservative treatment. The role of endovascular management may be defined in accordance with specific situations: curative therapy with embolization only; preoperative management using embolization before complete surgical excision, or before radiosurgery, and palliative embolization designed to diminish symptoms associated with the arteriovenous shunting or to eliminate elements that increase the risk of bleeding within the malformation complex ([20-21]).

In our study the majority of the patients were in the age group of 30-40 were 36% followed by 20-30 which were 24%, < 20 were 20%, 40-50 were 21%, 50-60 and >60 were 4% each.

The majority of the patients were Male i.e. 68% followed by Female 32%. The most common symptoms were Headache in 76% followed by, Vertigo in 68%, Seizure In 44%, Tinnitus in 36%, Blurred image in 32%, Difficulty in speaking in 20% and Photophobia in 12%.

The majority of the patients were having the GCS in 9-12 were 48%, followed by 12-15 were 28%, 6-9 were 16%, 3-6 were 8%.

The majority of patients had Hess and Hunt classification grading 3 (44%). Grade 2 was seen in 24% patients followed by grade 1 which was seen in 16% patients. Grade 4 and 5 were seen in 8% patients each. The majority of patients had Spetzler Martin grading scale as grading 4 (36%). Grade 3 was seen in 28% patients followed by grade 5 which was seen in 20% patients. Grade 2 was seen in 12% patients and Grade 6 were seen in 4% patients.

Medium sized Cerebral AVMs were seen in 40% patients. Large AVMs were seen in 32% patients. 20% patients had small AVMs. Giant AVMs were seen in only 8% patients.

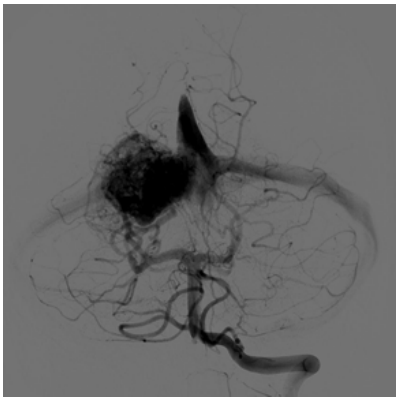
Majority (40%) of Cerebral AVMs were located in the dominant cerebral hemisphere. 32% were located in the non dominant cerebral hemisphere. 12% Cerebral AVMs were noted in basal ganglia.

8 patients were referred for radiosurgery (32%). Thus, 17 patients were cured in either 1 or 2 settings (68%).Thus, embolization may also be performed prior to radiosurgery to reduce the size of AVM. Small AVMs usually are completely obliterated in 1 setting alone while large AVMs usually require 2 or more setting to achieve complete obliteration. Palliative emoblization was done in 1 patient to attempt seizure control, for the AVM was not amendable to radiotherapy.

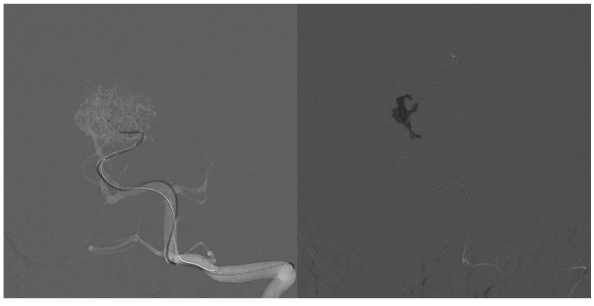
Endovascular therapy is a minimally invasive procedure with good cure rate. Few disadvantages of endovascular embolization are incomplete embolization, procedure complications like intracranial ahemorrhage etc. which might raise the chances of mortality.

CONCLUSION –

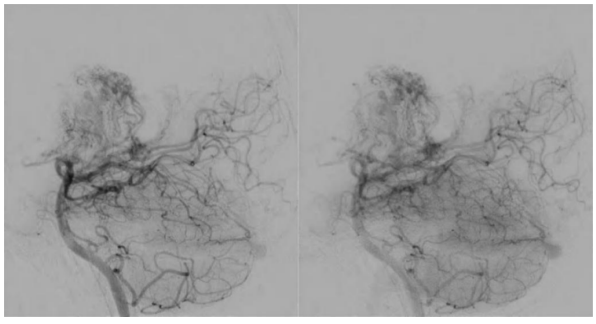
Treatment of Cerebral AVM in modern times is a multimodality approach, with a team consisting of physicians with expertise in endovascular intervention, cerebrovascular neurosurgery, and radiation therapy. Endovascular embolization has become a crucial component of management of Intra-cranial AVM, either as a stand-alone curative method or as an adjunct to microsurgery or radiosurgery, with few complications. Endovascular treatment of brain AVM are likely to expand as new embolic agents are becoming available and new microcatheters are being designed.



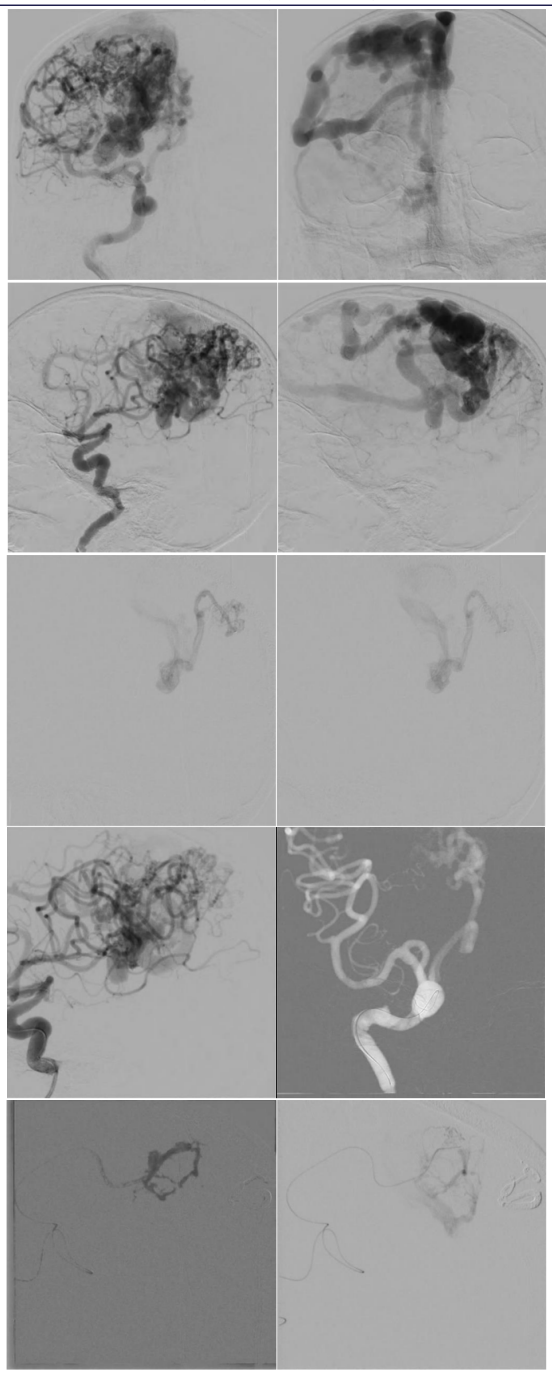
CASE I: 12 year old female, GCS -15/15, 4 Vessel DSA reveals a Cerebral AVM supplied by branches of right MCA and right Vertebral artery; with venous drainage into inferior sagittal sinus and straight sinus causing its aneurysmal dilatation



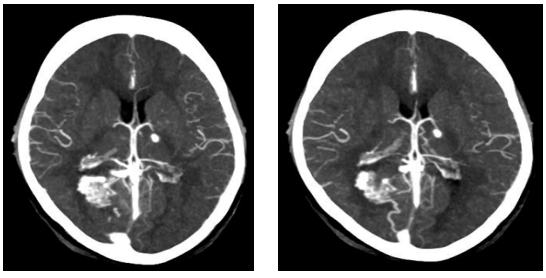
4 vessel DSA while doing embolization using microcatheter and OYNX.



CASE II:19 year old male, GCS score 7/15. 4 vessel DSA reveals a Cerebral AVM supplied by branches of posterior cerebral artery draining into transverse sinus and superior sagittal sinus causing its aneurismal dilatation.

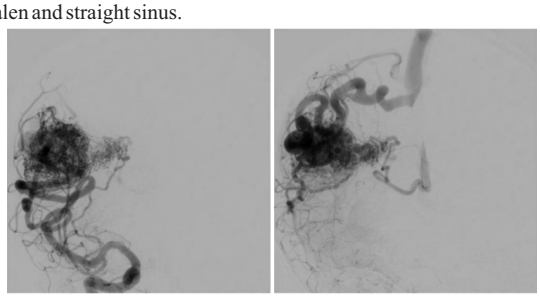


CASE III: A 40 year old male with complains of epilepsy and headache, 4 vessel DSA reveals a high flow AVM extensively involving the right temporo-parietal region of right cerebral hemisphere with multiple flow related venous aneurysms and venous drainage into superior sagittal sinus through dilated tortuous cortical veins. DSA images during embolization by ONYX.



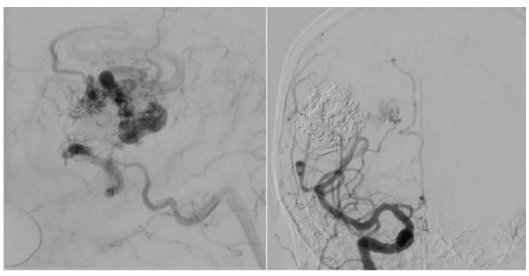
CASE IV: A 30 year old female, CT angiography reveals a deep seated AVM in posteromedial aspect of parieto-occipital lobe feeded by

calcarian branch of right PCA and the vein is draining into vein of Galen and straight sinus.



4 Vessel DSA reveals a Cerebral AVM feeded by calcarian branch of right PCA and the vein is draining into vein of Galen and straight sinus.

4 Veseel DSA during embolization by onyx using microcatherter in the same patient.



Dose Report | ClarityIQ

Dose exposure table*

Series	Date & Time	Description	DAP Gy· cm²	K [mGy]	No of images	Rot	Ang	fps	mA	ms	mAs	kV	SID [Cm]	Prefilter
1	13/08/2018 15:08	Left Coronary 15 fps Normal	1.84	9.96	73	LAO 1°	0°	15.0	288	4		65	89	0.0 mm Cu + 0 mm Al
2	15:13	Left Coronary 15 fps Normal	2.07	24.7	85	LAO 90°	0°	30.0	356	8		66	119	0.0 mm Cu + 0 mm Al
3	15:16	Left Coronary 15 fps Normal	0.483	3.98	29	LAO 90°	0°	15.0	305	4		65	120	0.0 mm Cu + 0 mm Al
4	15:16	Cerebral 6 fps Normal	9.42	77.7	30	LAO 90°	0°	2.0			19	75	120	0.0 mm Cu + 0 mm Al
5	15:17	Cerebral 6 fps Normal	19.1	168	29	0°	CRAN 33°	2.0			42	75	96	0.0 mm Cu + 0 mm Al
6	15:18	Cerebral 6 fps Normal	16.9	161	27	RAO 38°	CRAN 27°	2.0			43	75	100	0.0 mm Cu + 0 mm Al
9	15:32	Cerebral 6 fps Normal	1.02	21.2	58	LAO 90°	0°	30.0	414	8		67	120	0.0 mm Cu + 0 mm Al
12	15:36	Cerebral 6 fps Normal	6.50	135	30	LAO 90°	0°	2.0			33	75	120	0.0 mm Cu + 0 mm Al
13	15:40	Cerebral 6 fps Normal	5.66	117	26	LAO 90°	0°	2.0			33	75	120	0.0 mm Cu + 0 mm Al
14	15:40	Cerebral 6 fps Normal	4.78	99.0	22	LAO 90°	0°	6.0			33	75	120	0.0 mm Cu + 0 mm Al
15	15:42	Cerebral 6 fps Normal	0.599	12.4	34	LAO 90°	0°	30.0	413	8		67	120	0.0 mm Cu + 0 mm Al
21	15:42	Cerebral 6 fps Normal	0.420	8.68	23	LAO 90°	0°	30.0	427	8		67	120	0.0 mm Cu + 0 mm Al
28	15:43	Cerebral 6 fps Normal	2.25	46.6	110	LAO 90°	0°	30.0	455	9		68	120	0.0 mm Cu + 0 mm Al
34	15:44	Cerebral 6 fps Normal	7.74	160	28	LAO 90°	0°	2.0			42	75	120	0.0 mm Cu + 0 mm Al
35	15:44	Cerebral 6 fps Normal	0.706	14.6	33	LAO 90°	0°	30.0	468	9		68	120	0.0 mm Cu + 0 mm Al
42	15:46	Cerebral 6 fps Normal	0.785	16.2	34	LAO 90°	0°	30.0	493	9		68	120	0.0 mm Cu + 0 mm Al
46	15:47	Cerebral 6 fps Normal	0.762	15.8	32	LAO 90°	0°	30.0	502	9		69	120	0.0 mm Cu + 0 mm Al

Note: stored fluoroscopy series are not visible in this overview.
For cumulative dose information related to fluoroscopy, see the first page of the overview.