Pressure Cooker Technique for Endovascular Treatment of Spinal Arteriovenous Fistulas: Experience in 15 cases

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Abstract

Background and Purpose:

Spinal arteriovenous fistulas (SAVFs) are challenging to cure by endovascular means, with a significant risk of incomplete occlusion or delayed recurrence. The authors report herein their preliminary experience using the pressure cooker technique (PCT) for the embolization of SAVFs.

Materials and Methods:

Fifteen patients (8 males, mean age = 60.3 y) underwent an endovascular treatment of a SAVF (12 dural SAVFs [DSAVFs] and 3 epidural SAVF [ESAVFs]) in 2 different institutions using the PCT. Two microcatheters could be navigated in the segmental artery in all patients using two guiding catheters. A proximal plug was achieved with highly concentrated cyano-acrylate $\pm$ coils. The liquid embolic agent injected to cure the fistula was diluted cyano-acrylate (n=11) or ethylene vinyl alcohol (EVOH) (n=4).

Technical and clinical complications were systematically recorded. Clinical and angiographic outcomes were systematically evaluated at follow-up.

Results:

One (6.7%) procedure-related complication was recorded, which consisted in a transient radicular deficit, related to nerve root ischemia.

Clinical improvement was observed in 10/14 (71%) of the patients for whom clinical follow-up was available.

Complete SAVF occlusion on follow-up angiogram was observed in 11/12 patients (91.7%) for whom angiographic follow-up was available. One patient (8.3%) presented a delayed recurrence at 29 months.

Conclusion:

PCT is a feasible technique, either with glue or EVOH, for the embolization of SAVFs. Our results suggest the safety and effectiveness of this technique.

Key words:

Malformation, Spinal Cord, Vascular Malformation, Fistula

Abbreviations and acronyms:

AV: arteriovenous, **DSAVF:** dural spinal arteriovenous fistula, **ESAVF:** epidural spinal arteriovenous fistula, **EVOH:** ethylene vinyl alcohol, **nBCA:** n-butyl cyano-acrylate, **PCT:** pressure cooker technique, **SAVF:** spinal arteriovenous fistula.

Introduction:

Spinal arteriovenous fistulas (SAVFs) are rare vascular malformations involving the spinal cord and corresponding to an abnormal arteriovenous (AV) shunt between spinal dural arteries and the radicular vein or the epidural venous plexus, which “contaminates” secondarily the spinal venous drainage.^{1 2} Most of these SAVFs are clinically revealed by a venous congestion, responsible for progressive sensory and/or motor deficits of the inferior limbs, often associated with sphincter disturbance (i.e.: urinary/fecal incontinence, sexual impotence).³

The best treatment option for SAVFs is still a matter of debate since no randomized controlled trial has compared endovascular treatment and surgery.⁴ Even if being minimally-invasive, the main drawback of the endovascular treatment is the risk of incomplete occlusion of the shunt point, which may lead to treatment failure or recurrence.⁵

The pressure cooker technique (PCT) has been developed to improve the penetration of liquid embolic agents in the embolization of brain arteriovenous malformations (AVMs), increasing the occlusion rate in endovascular treatment of brain AVMs.⁶

The purpose of our study was to report our experience of the PCT for the endovascular treatment of SAVF.

Materials and Methods:

Patient selection:

All patients treated for a SAVF in 2 Institutions (Alfried Krupp Krankenhaus, Essen, Germany and Pitié-Salpêtrière Hospital, Paris, France) from 2012 to 2020 by endovascular means were systematically reviewed.

Patient's demographics (age, sex) as well as clinical revealing symptoms and the time interval between symptoms onset and endovascular treatment were systematically recorded.

Clinical evaluation:

Pretreatment clinical examination was systematically performed by a neurologist, who was not directly involved in the endovascular treatment. Clinical symptoms, as well as duration between symptoms appearance and SAVF diagnosis, were systematically recorded. Symptoms' severity was evaluated using the Aminoff-Logue scale.⁷

Endovascular procedures:

All the patients were treated under general anesthesia, via a bilateral 5F femoral access under full anticoagulation. A first 5F catheter (usually a Cobra Small catheter or a Simmons [1 or 2] catheter) was positioned at the ostium of the segmental artery feeding the SAVF. A microcatheter (1.2F or 0.017") was navigated in the segmental artery. The 5F catheter was then disengaged from the ostium of the segmental artery but kept at that level. A second 5F guiding catheter was positioned at the ostium of the same segmental artery. A second microcatheter was then navigated in the segmental and later in the radiculomeningeal artery as close as possible to the shunt point. To reduce the risk of embolic agent migration, coils were placed through the first microcatheter in the main trunk of segmental artery, distally to dorso-spinal trunk's origin

and/or the dorsal branch of the segmental artery. Afterwards, a proximal “plug” was performed using high concentrated n-butyl cyano-acrylate (nBCA) (i.e.: 50% nBCA in combination to Lipiodol) (**Fig. 1**). The fistula was then occluded by injection of low concentrated nBCA (20% nBCA, 80% Lipiodol) (n=11) (**Fig. 2**) or an ethylene vinyl alcohol (EVOH) copolymer (n=4) (**Fig. 3**) through the second microcatheter. Injection was maintained until occlusion of the draining vein’s origin.

For SAVFs embolized with the PCT using glue as liquid embolic agent, no detachable tip microcatheters were used (Echelon 10 [Medtronic, Irvine, CA] or the Marathon [Medtronic]). On the contrary, when EVOH was used to occlude the fistula, a detachable tip microcatheter was systematically used (Apollo microcatheter, Medtronic, Irvine, CA).

Feasibility and safety:

Technical failures/complications were systematically recorded. Complications were systematically assessed and graded using the CIRSE and SIR complication guidelines.⁸ Briefly, this classification is a 6 scales grading system evaluating the severity of the complication; grade 3 being a complication requiring additional postprocedure therapy or prolonged hospital stay (48 h) but with no sequelae, grade 4 being a complication causing a permanent mild sequelae and grade 5 being a complication causing a permanent severe sequelae.

Clinical and imaging follow-up:

Clinical examination was performed 3 months or more after the procedure, in most cases by the operator who performed the procedure.

Spinal DSA was performed systematically at 3 months or more to rule out a SAVF recurrence.

Statistical analysis:

Data were reported as mean $\pm$ standard deviation (SD) for continuous variables and median with interquartile range (IQR) for non-continuous variables.

All tests were calculated using Stata software (Stata/IC 13.1 for Mac; StataCorp LP); p values less than 0.05 were considered statistically significant.

Ethical statement:

The choice to treat these patients by endovascular means was made through a multidisciplinary meeting including neurosurgeons and interventional neuroradiologists. Patients were informed before each treatment of the strategy that was chosen and gave an oral consent.

This work received approval from our institutional review board (IRB) (IRB approval # HH 16_4_20b). The need for patients' informed consent for retrospective analyses of records and imaging data was waived by our IRB. This work adheres to the World Medical Association Declaration of Helsinki.

Results:

Patients' demographics:

Among the patients treated for a spinal AV fistula in the 2 institutions during the inclusion period, 15 patients (8 males [53%] mean age: 60.3±16.7 years) were treated using the PCT (**Table 1**). The PCT was chosen in these patients due to the inability to bring the microcatheter in a wedge flow position with a risk of poor progression of the liquid embolic agent beyond the shunt. In 2/15 cases (13.3%) the embolization was performed after a recurrence in patients previously treated by nBCA injection without the PCT. Interestingly, 2 patients (13.3%) were previously treated surgically for a spinal canal stenosis.

In 60% of the patients (9/15), sensory symptoms (paresthesia, dysesthesia) were recorded; genito-urinary dysfunction (fecal and/or urinary retention) was observed in 53.3% of the cases (8/15). Inferior limbs motor weakness was observed in 40% of the cases (6/15). Finally, in 2 cases (13.3%), lumbar pain was recorded, for which there was no clear relationship with the SAVF.

Median Aminoff-Logue scale ⁷ score before exclusion treatment was 3 (IQR: 2-4.5) (senrory signs: median = 2 [IQR: 1.5-2.5]; micturion: median = 1 [IQR: 0-2]).

Angiographic features of the SAVF:

Most of the SAVFs were dural AVFs (12/15; 80%); the 3 remaining cases (20%) were epidural AVFs (**Table 2**). Most of the SAVFs were located at the thoracic level (9/15; 60%); 3 SAVFs (20%) were located at the lumbar level and 3 (20%) were sacral dural AVFs. In 46.7% of the cases (7/15) the venous drainage was purely ascending; in 7/15 cases (46.7%) both ascending and descending and in the remaining case (7%) purely descending.

Feasibility and safety:

No catheterization failure was recorded. Two guiding catheters could be successively placed in the segmental artery and a microcatheter further

Table 1. Clinical symptoms' and angiographic features

Patient nb	AV Fistula type	Interval symptoms-diagnosis (mo)	Symptoms at presentation	Aminoff-Logue ⁷ scale PreTx	Aminoff-Logue ⁷ PreTx sensory signs	Aminoff-Logue ⁷ PreTx micturition	Recurrence before Tx with PCT	Feeder(s)	Venous drainage
1	Epidural	48	LL dysesthesia, bladder disturbance, constipation	5	2	3	No	R L3	Ascending
2	Dural	6	LL paresthesia, constipation and bladder disturbance	2	1	1	Yes	L T6	Ascending & descending
3	Dural	1	LL motor and sensory deficit	2	2	0	No	R T6	Ascending & descending
4	Dural	24	L buttock pain, LL paresthesia, bladder disturbance	3	2	1	Yes	R T6	Descending
5	Epidural	36	Dysesthesia, constipation, bladder disturbance	4	2	2	No	L L1	Ascending
6	Dural	-	Lumbar pain not related, no spinal edema on MR	0	0	0	No	L lat. sacral artery	Ascending
7	Dural	6	Dysesthesia left arm	0	0	0	No	L T4	Ascending
8	Dural	36	LL paresthesia, constipation and bladder disturbance	4	2	2	No	R T11	Ascending & descending
9	Dural	6	Slight LL weakness	4	4	0	No	L T9	Ascending & descending
10	Dural	60	Complete motor deficit right LL, mild paresis left LL, bladder and fecal incontinence	5	3	2	No	R T11	Ascending & descending
11	Dural	20	Bilateral paresthesia	2	2	0	No	L lat. sacral artery	Ascending
12	Dural	3	LL weakness, no retention	2	2	0	No	L T5	Ascending & descending
13	Epidural	7	LL weakness & urinary retention	3	1	2	No	L lat. sacral artery	Ascending
14	Dural	8	LL weakness & urinary retention	6	4	2	No	R L1	Ascending
15	Dural	2	LL weakness, paresthesia	5	5	0	No	R T11	Ascending & descending

Nb indicates number; AV: arteriovenous; mo: months; LL: lower limbs; PreTx: pretreatment; Tx: treatment; PCT: pressure cooker technique; R: right; L: left; lat.: lateral.

Table 2. Pressure cooker technique details; clinical and angiographic outcomes

Patient nb	Proximal plug for PCT	Embolic agent injected	Technical complication	Clinical complication	Clinical outcome	Delay clinical FU (mo)	Aminoff-Logue ⁷ scale Post-Tx	Aminoff-Logue ⁷ PostTx sensory signs	Aminoff-Logue ⁷ PostTx micturition	Angiographic FU results	Delay angiographic FU (mo)
1	Coils + nBCA 50%	Squid 12	0	Radicular pain and R leg motor deficit	Clinically unchanged	5	5	2	3	Complete occlusion	5
2	Coils	Onyx	0	0	Improvement sensory disorders and bladder dysfunction	4	1	1	0	Complete occlusion	4
3	Coils + nBCA 50%	Onyx	0	0	Improvement persistence LL sensory disorder	7	1	1	0	Complete occlusion	7
4	Coils + nBCA 50%	Onyx	0	0	Clinically unchanged	4	3	2	1	Complete occlusion	4
5	nBCA 50%	nBCA 20%	0	0	Death at one month from myocardial infarction	NA	NA	NA	NA	NA	NA
6	nBCA 50%	nBCA 20%	0	0	Asymptomatic	3	0	0	0	Complete occlusion	3
7	nBCA 50%	nBCA 20%	0	0	Asymptomatic	10	0	0	0	Complete occlusion	3
8	nBCA 50%	nBCA 20%	0	0	Clinical improvement paresthesia	13	3	1	2	Complete occlusion	13
9	nBCA 50%	nBCA 20%	0	0	Improvement sensory disorders	1	3	3	0	NA	NA
10	Flow coils + nBCA 50%	nBCA 20%	0	0	Partial regression hypoesthesia, motor deficit unchanged	14	5	3	2	NA	NA
11	nBCA 50%	nBCA 20%	0	0	Clinically unchanged	3	2	2	0	Complete occlusion	3
12	nBCA 50%	nBCA 20%	0	0	Back to normal at 3 months with 7 km walking per day	3	0	0	0	Complete occlusion	3
13	nBCA 50%	nBCA 20%	0	0	Initial improvement for 18 months, recurrence after 2 years	29	1	0	1	Recurrence at 29 months	29
14	Coils + nBCA 50%	nBCA 20%	0	0	Immediate minor clinical improvement	3	6	4	2	Complete occlusion	3
15	nBCA 50%	nBCA 20%	0	0	Minor clinical improvement	3	5	5	0	Complete occlusion	3

Nb indicates number; nBCA: n-butyl cyano-acrylate; mo: months; FU: follow-up; Tx: treatment; PCT: pressure cooker technique; NA: not available.

navigated in all patients. The embolic agent could be brought up to the vein in 14/15 patients (93.3%).

The retrieval of all microcatheters was uneventful. Specifically, no glued microcatheter or reflux of embolic agent in the aorta was reported.

No major complication was recorded in our series. Only one minor complication (grade 3 in the CIRSE/SIR classification ⁸) was observed, which consisted in a L3 nerve root lesion revealed by pain and motor deficit in a L3 epidural AVF. This complication was reversible; the patient recovered under anti-inflammatory medication with no sequelae.

Immediate angiographic outcome/imaging follow-up:

Immediate complete occlusion of the SAVF was observed in 15/15 cases. No residual shunt was depicted at the end of the procedure in any case.

Follow-up spinal DSA was available in 12/15 patients (80%) at a mean time interval of 6.7 ± 7.6 months from the procedure (range: 3-29). Complete persistent occlusion of the AVF was observed 11/12 cases (91.7%).

Clinical follow-up:

Clinical follow-up was available in 14/15 patients (93.3%), with a mean time interval of 7.3 ± 8.4 months (range: 3-29). One patient died at one month from a myocardial infarction.

Patients experienced clinical improvement in 71.4% of the cases (10/14). Three patients (21.4%) were stable, and one patient (7.2%) presented a delayed clinical worsening at 29 months, related to a SAVF recurrence, which was subsequently treated by microsurgery.

Median Aminoff-Logue ⁷ scale at clinical follow-up was 2.5 (IQR: 1-4.5) (sensory signs: median = 1.5 [IQR: 0.25-2.75]; micturition: median = 0 [IQR: 0-1.75]).

Discussion:

Embolization of dural/epidural AV fistulas may be challenging. The two major drawbacks for SAVFs embolization are: 1) the non-controlled embolic agent migration into a radiculomedullary artery, potentially responsible for neurologic complications and 2) incomplete occlusion of the shunt point, with unrecognized persistent SAVF and clinical worsening. This delay may finally hamper the recovery of the patient's symptoms.⁹ A recent meta-analysis¹⁰ showed that among patients treated for SAVFs, surgery had better results in terms of complete occlusion and clinical outcome as compared to endovascular embolization. Indeed, SAVF recurrence was observed ranging up to 3.7% of the cases with surgery treatment vs. up to 40% with embolization.¹⁰ Additionally, in patients treated by endovascular means, the same meta-analysis showed that the risk of failure/late recurrence was higher with EVOH than with nBCA (OR 3.87, CI; 1.73 to 8.68, $p < 0.001$).¹⁰ Indeed, the chance to penetrate distally when using EVOH is lower (without using a PCT) since important reflux is often seen, toward the aorta, prompting the operator to stop the injection, despite non-occlusion of the shunt point. These results lead some interventional neuroradiologist to discourage endovascular option as a first line treatment and to prefer surgery.¹¹ Our experience in the embolization of intracranial vascular malformations using the PCT led us to use this technique in SAVF.

The Pressure Cooker Technique has been first described for the embolization of intracranial vascular malformations.⁶ Its principle is to combine two liquid embolic agents that do not interact. The goal is first to avoid an excessive and uncontrolled retrograde reflux of embolic agent and second to increase the distal diffusion of the embolic agent. The potential of the PCT for the embolization of SVMs has only been assessed in oral presentations up to now.¹²

Unlike the initial description of PCT, we did not only use EVOH but also low concentrated nBCA as embolic agent for the SVM. This was left to the discretion of the operator. The advantage of using EVOH copolymer is its better visibility under blank road map. On the other hand, the advantage of using nBCA is that there is no need for DMSO, and thus, non-DMSO compatible microcatheters like Magic 1.2 (Balt Extrusion, Montmorency, France) can be used for embolization. In our

opinion, the type of embolic agent to be used for the fistula embolization is not of major importance, as long as it does not dissolve the plug and has a high ability to diffuse, as with EVOH or low concentrated nBCA.

For SAVFs embolized with the PCT using glue as liquid embolic agent, no detachable tip microcatheters were used. The retrieval of microcatheters in the segmental arteries was uneventful, without elongation of arteries and high retraction forces. Neither excessive force nor rupture of the microcatheter's tip occurred when retrieving the non-detachable microcatheters despite the proximal plug of polymerized high concentrated nBCA. In our previous experience of using the pressure cooker technique outside pial cerebral vessels, we noticed that retrieval of microcatheters was uneventful such as in the meningeal or occipital arteries. We attribute the ease of retrieval to the combination of a short length of the plug and a straight course of the microcatheter. The Echelon microcatheter is braided but not the Marathon, so ease of retrieval cannot be attributed to the braiding. On the contrary, a detachable tip microcatheter should systematically be used for PCT in pial branches. Indeed, the cerebral gyri are responsible for the tortuous course of the cerebral pial arteries. This course is straightened during the retraction of a microcatheter, even more so if its tip has been trapped by EVOH or nBCA, potentially inducing bleeding from ruptured transmedullary arteries.

For SAVFs treated with EVOH, detachable tip microcatheters were used to avoid trapping, since the EVOH was injected over a long time period, with a significant proximal reflux.

The main technical drawback for the use of PCT in SAVFs is the need for two microcatheters. Since segmental arteries are usually too narrow to allow cannulation with a regular 6F guiding catheter which would allow 2 microcatheters, two 5F-guiding catheters are required for the PCT. Thus, after placement of the first micro-catheter in the segmental artery, the guiding catheter has to be disengaged from the ostium in order for the second guiding catheter to be positioned at the origin of the segmental artery for navigation with the second microcatheter (**Fig. 1**). The use of a mini stent retriever, compatible with a 0.017" microcatheter, was helpful to stabilize the first microcatheter and the first guiding catheter in some patients (**Fig. 3**).

The use of a dual lumen balloon may be an alternative to PCT for SAVFs embolization.¹³ It may help to overcome the limitation of using 2 guiding catheters. However, the dual lumen balloons available on the market may be difficult to navigate in small and tortuous vessels, as can be the segmental arteries. Smaller dual lumen balloons, with a low profile, may help to overcome this limitation.

Feasibility, safety and effectiveness:

Embolization of SAVFs was feasible using the PCT in all cases; no technical failure was recorded: it was possible to navigate 2 microcatheters in all patients including elderly patients aged up to 91 years. It was possible to fill the origin of the main draining vein in 14/15 patients (93.3%).

Only one minor complication (6.6%) was recorded, consisting in a transient nerve root lesion, probably related to an ischemic mechanism. No major complication was recorded.

Occlusion of the fistula was observed in all cases (15/15) at the end of the procedure.

At angiographic follow-up (available in 12/15 cases [80%], average time interval = 6.7 ± 7.6 months) a persistent complete occlusion was found in 11/12 (91.7%) cases. A recurrence occurred in the only patient with an ESAVF in whom the embolic agent did not completely reach the vein.

The filling of the origin of the draining vein with embolic agent seems therefore to be the main criteria to assess an endovascular cure.

The avoidance of reflux, as achieved with the PCT, allows an increased diffusion of the embolic agent. The ability to see the opening of anastomoses is reduced by respiratory artefacts that alter the quality of the blank roadmap used during injection. Therefore, additional precautions, such as prolonged apnea, may be taken during injection. This is specifically important in case of a spinal artery arising from the contralateral segmental artery or from a segmental artery one level below or above the SAVF. In these situations, migration of embolic agent toward a radiculo-medullary artery may occur as retrocorporeal or

intersegmental anastomoses are always present.¹⁴ To prevent such uncontrolled embolic agent migration, preventive selective coiling of these anastomoses may be achieved before liquid embolic agent injection.

Limitations of the study:

The main limitations of our study are the retrospective design and the limited number of patients and centers included. Additionally, comparison with the standard therapy (i.e.: microsurgery) for the curative treatment of SVMs is lacking. Moreover, the SVMs treated in our series were heterogeneous, including both dural and epidural AVFs. Techniques used were also slightly heterogeneous since in some patients, the liquid embolic agent used was diluted nBCA and in others, EVOH. Moreover, the fact that angiographic follow-up is missing in 20% of the cases is another limitation of our study.

Conclusion:

The Pressure Cooker Technique to treat spinal arteriovenous fistulas, either with glue or EVOH, may improve the rate of complete endovascular cure. A prospective head-to-head comparison with microsurgery appears warranted.

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Figure captions:

Figure 1.

Drawing summarizing the different steps for the Pressure Cooker Technique (PCT) in spinal vascular malformation embolization.

A. Positioning the microcatheter # 1 (for coiling) distally in the main trunk of the segmental artery, via the guiding catheter # 1. **B.** The guiding catheter # 1 is disengaged from the segmental artery's ostium. **C.** The guiding catheter # 2 is subsequently positioned at the ostium of the segmental artery. **D.** The microcatheter # 2 (dedicated to the liquid embolic agent injection for the arteriovenous fistula treatment) is navigated via the guiding catheter # 2 as close as possible to the shunt point. **E.** Coiling of the main trunk is performed via the microcatheter # 1 until occlusion. **F.** and **G.** Dorsal branch, and then the dorso-spinal trunk, are subsequently coiled until occlusion via the microcatheter # 1 to obtain the proximal plug of the pressure cooker. **H.** and **I.** Liquid embolic injection via the microcatheter # 2 is performed until the filling of the draining vein's origin.

Figure 2.

Patient in its 40's presenting with lower limbs paresthesia, constipation and bladder disturbance lasting for 36 months.

A. Spinal cord MRI; T2-weighted images (WI); sagittal slice showing the hyperintense signal of the spinal cord extending up to T8 and multiple flow-void signals in the enlarged spinal veins. **B.** Spinal DSA; right T11 angiogram in postero-anterior (PA) projection showing a spinal AV fistula with both ascending and descending venous drainage. **C.** Navigation of the microcatheter # 1 (dedicated to the pressure cooker technique [PCT] plug) (black arrow). Then, the guiding catheter # 1 is disengaged from the right T11 intercostal artery (white arrow). The guiding catheter # 2 is subsequently positioned at the ostium the segmental artery (white arrowhead). **D.** Navigation of the second microcatheter (# 2) (black arrowhead) from the guiding catheter # 2 (white arrowhead), as close as possible to the shunt point. Note the tip of microcatheter # 1, located proximally to the tip of microcatheter # 2. **E.** Ultraslective angiogram in PA projection from the microcatheter # 2. The origin of the main draining vein (radicular vein) is clearly seen (double white arrow). **F.** PCT. Injection of 50% n-butyl cyano-acrylate (nBCA) through microcatheter # 1 to create the proximal plug (black arrow). Then, injection of 20% dilution nBCA is performed to embolize the fistula (white arrow). **G.** Plain X-Ray in PA projection showing the glue cast. Note the filling of the origin of the radicular vein (white arrows) and also the progression of the liquid embolic agent through the retrocorporeal anastomosis (white arrowhead). **H.** Right T11 angiogram at the end of the procedure showing a complete occlusion of the fistula. **I.** Spinal cord MRI 14 months after embolization; T2- WI; sagittal slice showing complete resolution of the spinal cord edema.

Figure 3.

Patient in its 60's presenting with a 4 year-history of paresthesia of the inferior limbs, bladder disturbance and constipation.

A. and **B.** Spinal cord MRI; T2-WI; sagittal (**A**) and axial (**B**) slices showing a centro-medullar hyperintense signal (white arrows) and lumbar spinal cord enlargement. **C.** and **D.** Spinal digital subtraction angiography (DSA); right L3 selective angiogram in postero-anterior (PA) projection at early phase (**C**) and intermediate phase (**D**). Numerous dural branches from the right L3 spinal trunk are depicted (**C**, white arrows) with abnormal connection with right aspect of the epidural plexus (**C**, *). Reflux from the anterior epidural plexus to a radicular vein is seen (**C** and **D**, black arrows), with an ascending drainage. **E.** Navigation of a 0.017" microcatheter via a 5F Simmons 1 catheter (with arrowhead). The microcatheter was stabilized by deploying a Catch Mini stent retriever (Balt, Montmorency, France) (black arrows); then the guiding catheter is gently pulled away from the right L3's ostium. **F.** An Apollo (5 cm detachable tip) microcatheter (Medtronic, Irvine, CA) is then navigated in the spinal trunk of the right L3 artery, as close as possible to the shunt point (black arrow); selective DSA via the Apollo microcatheter in PA projection. Note the guiding catheter (5F Simmons 1) at the ostium of right L3 artery (black arrowhead), while the second one is in stabilized in front of it (white arrowhead). Note the second 0.017" microcatheter, which has been left in the main trunk of right L3 artery (white arrows). **G** and **H.** Coiling, via the 0.017" microcatheter of the main L3 trunk (**G**, white arrow), then the dorso-spinal trunk (**G**, black arrow) and arterial segment before arising of the dorso-spinal trunk (**H**, white arrow) to obtain the proximal plug of the pressure cooker. Finally, 50% dilution nBCA injection was performed at the proximal aspect of the coils' cast through the 0.017" microcatheter (**I**, white arrow) to ensure that the proximal plug would be occlusive. Then, Squid 12 (Balt, Montmorency, France) was injected under blank road map through the Apollo catheter until occlusion of the shunt point along the anterior epidural venous plexus (**J** and **K**, white arrows) and the filling of the radicular vein's origin (**J**, black arrow). **L.** Plain X ray in PA projection at the end of Squid 12 injection showing the EVOH cast. **M.** Final control DSA in PA projection via the common trunk feeding both right and left L3 arteries, showing the complete occlusion of the fistula **N.** Post-procedure unenhanced CT-scan, bone windowing; sagittal reconstruction showing the EVOH cast in the anterior epidural venous plexus (white arrows).