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ORIGINAL

The role of Surgery in the treatment of spinal Dural Arteriovenous fistula

El papel de la cirugía en el tratamiento de la fístula arteriovenosa dural espinal

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ABSTRACT

The vascular abnormality known as a spinal dural arteriovenous fistula (SDAVF) is highly uncommon. To perceive the anomaly, the gold standard before surgical operations like vascular therapy or open surgical procedures involves computerized reduction imaging. Hidden SDAVFs on an angiogram have been documented before. There was no assessment of surgical options for SDAVFs with false-positive angiogram findings. Patients who underwent SDAVF surgery in 2018–2019 at a single institution had their medical records, and imaging trainings revised retrospectively. After failing endovascular embolization or worsening clinically and radiographically in the context of an angiographically hidden lesion, all patients were referred for surgical intervention. Surgery options for these lesions were explored after a thorough case assessment. There was a total of 4 cases in this series. Despite undergoing embolization before surgical repair, the neurological status of 2 patients deteriorated further, while embolization in 2 other patients was unsuccessful due to the complexity of their vascular systems. All four patients had their neurological conditions improve or remain stable after the examination. Microscopically integrated fluorescence angiography with indocyanine green injection helped identify the supplier's veins and proved the SDAVF closure. After an SDAVF has been identified, immediate treatment is necessary. If angiography results are unclear or raise doubts about the presence of SDAVF, an urgent spinal investigation should be performed. Indocyanine exploring spine surgery for SDAVF completion may benefit from green light micro angiography.

Keywords: Spinal Dural Arteriovenous Fistula (SDAVF); Medical Records; Radiograph; Surgical Repair; Fluorescence Angiography.

RESUMEN

La anomalía vascular conocida como fístula arteriovenosa dural espinal (FAVD) es muy poco frecuente. Para detectar esta anomalía, el método de referencia antes de intervenciones quirúrgicas como la terapia vascular o la cirugía abierta consiste en la obtención de imágenes de reducción computarizada. Se han documentado FAVD ocultas en angiografías previas. No se evaluaron las opciones quirúrgicas para FAVD con hallazgos angiográficos falsos positivos. Los pacientes sometidos a cirugía de FAVD entre 2018 y 2019 en una sola

institución fueron sometidos a una revisión retrospectiva de sus historias clínicas y formación en imagenología. Tras el fracaso de la embolización endovascular o el empeoramiento clínico y radiográfico en el contexto de una lesión oculta angiográficamente, todos los pacientes fueron derivados a cirugía. Tras una evaluación exhaustiva de los casos, se exploraron las opciones quirúrgicas para estas lesiones. Esta serie incluyó un total de 4 casos. A pesar de someterse a una embolización antes de la reparación quirúrgica, el estado neurológico de dos pacientes se deterioró aún más, mientras que la embolización en otros dos pacientes no tuvo éxito debido a la complejidad de sus sistemas vasculares. Los cuatro pacientes experimentaron una mejoría o estabilidad de su estado neurológico tras el examen. La angiografía por fluorescencia microscópicamente integrada con inyección de verde de indocianina ayudó a identificar las venas del proveedor y confirmó el cierre de la FAVD. Tras el fracaso de la embolización endovascular o el empeoramiento clínico y radiográfico en el contexto de una lesión oculta angiográficamente, todos los pacientes fueron derivados a intervención quirúrgica. Tras una evaluación exhaustiva de los casos, se exploraron las opciones quirúrgicas para estas lesiones. En esta serie se incluyeron un total de 4 casos. A pesar de la embolización antes de la reparación quirúrgica, el estado neurológico de 2 pacientes se deterioró aún más, mientras que la embolización en otros 2 pacientes no tuvo éxito debido a la complejidad de sus sistemas vasculares. Los cuatro pacientes experimentaron una mejoría o estabilidad de su estado neurológico tras la exploración. La angiografía de fluorescencia microscópicamente integrada con inyección de verde de indocianina ayudó a identificar las venas del proveedor y confirmó el cierre de la FAVD. Tras la identificación de una FAVD, es necesario un tratamiento inmediato. Si los resultados de la angiografía no son claros o plantean dudas sobre la presencia de una FAVD, se debe realizar una exploración espinal urgente. La cirugía de columna exploratoria con indocianina para la finalización de la FAVD puede beneficiarse de la microangiografía con luz verde.

Palabras clave: Fístula Arteriovenosa Dural Espinal (FAVD); Registros Médicos; Radiografía; Reparación Quirúrgica; Angiografía con Fluorescencia.

INTRODUCTION

The incidence of spinal dural arteriovenous fistula (SDAVF), an uncommon myelopathy, ranges from 5 to 1 in a million each year. It makes up around 70 % of all spinal vascular disorders and is the most frequent spinal arteriovenous malformation. The incidence of SDAVF is rising each year due to the aging population and greater awareness of this illness. The thoracolumbar junction is where the fistula most frequently develops, and it is more common in males over 30. The primary pathogenic cause of SDAVF is venous hypertension myelopathy (VHM), which causes persistent and progressive spinal damage. Patients typically exhibited sensory impairment, gradual flaccid paraplegia, and irregular urine and excretion.[1] Considered a treatable cause of myelopathy, SDAVFs. Treatment for SDAVF involves surgically or endovascularly blocking the shunt between the artery and vein. Finding the source of the shunting presents the biggest surgical challenge[2] Despite the possibility of error, sequential spinal radiography remains the gold standard for identifying SDAVF. Diagnostic using the radiologist's focus and the clinician's suspicion during magnetic resonance imaging (MRI). The location of the vascular lesion and its treatment are determined by an angiogram. For the treatment of SDAVF, surgical procedures and endovascular embolization are efficient techniques.[3] Previous studies on SDAVFs mainly compared the results of surgery and endovascular therapy, the two therapeutic options. Surgery is still the best treatment option for managing these lesions, according to a recent meta-analysis10; however, it is still unclear which patient features before treatment will be most strongly associated with the post intervention outcomes.[4]

Because of this, we quantitatively compared and contrasted with the effects of endovascular treatment and microsurgical treatment for SDAVF patients but also the impact of initial treatment success on patient outcomes. Additionally, we looked into the causes of early therapy failure.[5] Despite being known as a cause of gait disruption, SDAVFs provide a diagnostic challenge due to their rarity. Due to an improper link between the radiculomeningeal arteries and a single intradural vein, SDAVFs are caused by venous congestion of the spinal cord.[6] SDAVFs, or spinal dural arteriovenous fistulas, was examined aberrant the point of fistulization, which typically occurs at the dural sleeve of the nerve root, just below the base of the vertebral body, creates a shunt connecting the meningeal artery and the curricular vein.[7,8] Looked into how pre- and postoperative MRI results affect the prognosis of patients with surgically repaired SDAVFs. Developing a therapeutic choice required classifying the venous drainage pattern. Large superior venous draining produces the best transvenous embolization outcomes.[9] If vascular therapy is not a possibility, surgical cutting could be a successful therapy for the illness.[10] During surgery for dural and peri medullary arteriovenous fistulas (AVFs), it is necessary to confirm the precise position of a fistula and the origins of draining veins. However, this is occasionally not done correctly, which can lead to incomplete eradication of the lesion. The exceptional to have an SPV DAVF or superior petrosal vein dural arteriovenous fistula. Its clinical manifestation, imaging features, treatment

choices, and risk factors are, therefore, unknown.[11] They discussed and look at the qualities of an SPV DAV described above.[12] The risk of SDAVF should be considered, especially in patients with intermittent spinal nerve damage and dysuria. Orthopedic surgeons need to be aware of the distinct clinical features, spinal cord edema, and flow defects on MRI of an SDAVF. Due to the previous doctors' and radiologists' failure to recognized the SDAVF's fundamental characteristics in the spine's magnetic resonance imaging, the diagnosis was delayed.[13,14] The standard primary origin of the typical radiculomedullary arteries appears more clearly depicted in the slab MIP and flat panel detector images. SDAVF can be safely treated with thorough analyses.[15] Describe the disease progression, diagnosis, and management of individuals with primary gastric lymphoma are covered, focusing on the evolving function of surgery. Individuals having high-risk early-stage or advanced gynecological cancer often required an integrative approach to treatment. Although the moderate chemosensitivity of epithelial ovarian cancer is widely recognized, what sets it apart from other spreading solid tumors is the strong correlation between surgical cytoreduction of tumor volume and increased patient survival.[16] The goal of was to evaluate the effectiveness of medical removal of brain metastases that result from extracranial primary malignancy, which underwent tumor removal followed by radiation therapy, or the radiation group, which underwent needle aspiration and treatment.[17,18] Concluded that most patients who received endovascular or surgical treatment for SDAVFs experienced positive and long-lasting clinical outcomes. In certain instances, complete blockage of the SDAVF needed a subsequent neurosurgery strategy after endovascular therapy. The objective of clinical improvement was often significant for patients who received surgery or endovascular therapy but minimal for those who underwent treatment crossover.[19] Clinical improvement appears to be related to the degree of myelopathy.[20] Preliminary discussion of anticoagulant therapy (AC) effectiveness and safety following the treatment of SDAVF has been found in the literature. It analyzes 4 cases in this series. Despite undergoing embolization before surgical repair, the neurological status of two patients deteriorated further, while embolization in two other patients was unsuccessful due to the complexity of their vascular systems. After an SDAVF has been identified, immediate treatment is necessary. If angiography results are unclear or raise doubts about the presence of SDAVF, an urgent spinal investigation should be performed.

METHOD

Patients who underwent SDAVF surgery at a single facility in 2018-2019 were included in a retrospective review of records, MRI scans, DSAs, endoscopic microscopy videos of the eyes, and operative reports. The ritual was successfully performed. Everyone was put on the surgical waiting list. When an angiographically undetected lesion fails to respond to endovascular embolization or when localized symptoms and radiographic worsening develop. It analyzed health, surgical, and radiological data from the past and built a preliminary surgery algorithm to find a common thread that might be used to improve future treatment algorithms. A fistula with an active flow was discovered while investigating the next level, D12-L1. The blood supply was coagulated and severed. Light red coloration appeared in the arterialized veins around the cord after closure. A fistula with an active flow was discovered while investigating the next level, D12-L1 the patient underwent exploratory surgery Two years and Three months after the first embolization. The blood supply was coagulated and severed. Light red coloration appeared in the arterialized veins around the cord after closure. The decision to explore surgical options for arteriovenous fistulas occurred at a discussion, including specialists from many fields. After postponing it for almost six months, the patient underwent exploratory surgery Two years and Three months after the first embolization. Before the treating surgeon requested a thoracic MRI, two rounds of lumbar MRI were completed. Severe cord edema was seen on a thoracic MRI. An angiography was recommended for the patient. Repeated spinal angiography indicated an L1 SDAVF on the left side. A painful procedure known as endovascular embolization was not successful. A neurological deficiency. The cardiovascular network made it challenging to reach the feeding artery from the ventricle.

Case 1

An 80-year-old man with a history of duodenal ulcer was admitted to the hospital because of progressive paraparesis and symmetrical lower limb dysesthesia. T2-weighted cord hyperintensity was observed on a thoracolumbar MRI which indicates indicative of intramedullary effusion as opposed to intravascular flow voids. The patient had a right-sided D12 arteriovenous fistula, as seen on spinal DSA. The abnormality was embolized using 0,4 cm3 of a 26 % Butyl cyanoacrylate solution. The patient's neurological function remained unchanged after a 3-year follow-up repeated and persistent MRI finding implies the potential for SDAVF. DSA has been done again, and it shows that at the correct D11 level, there is a fresh fistula of arteriovenous blood with a shallow flow, fed by several small branches entering through the middle D12 level. Due to the small diameter of the blood vessels, expanding the fistula was not an option.

After three years of monitoring, the patient's neurological condition remained unchanged. The patient's paralysis continued to worsen for three years following the embolization. DSA results from his follow-up examination were consistent with his prior angiography. The patient had exploratory surgery, during which a

laminectomy was performed on vertebrae, and a dural opening was made. A fistula with an active flow was discovered while investigating the next level, D12-L1. The blood supply was coagulated and severed. Light red coloration appeared in the arterialized veins around the cord after closure. The neurological condition of the patient enhanced after surgery. After two years of follow-up, he restored control of his gait and showed remarkable strength gains. Figure 1 depicts the Exploratory Surgery protocol for spinal dural arteriovenous fistulas that are hidden or deceptive.

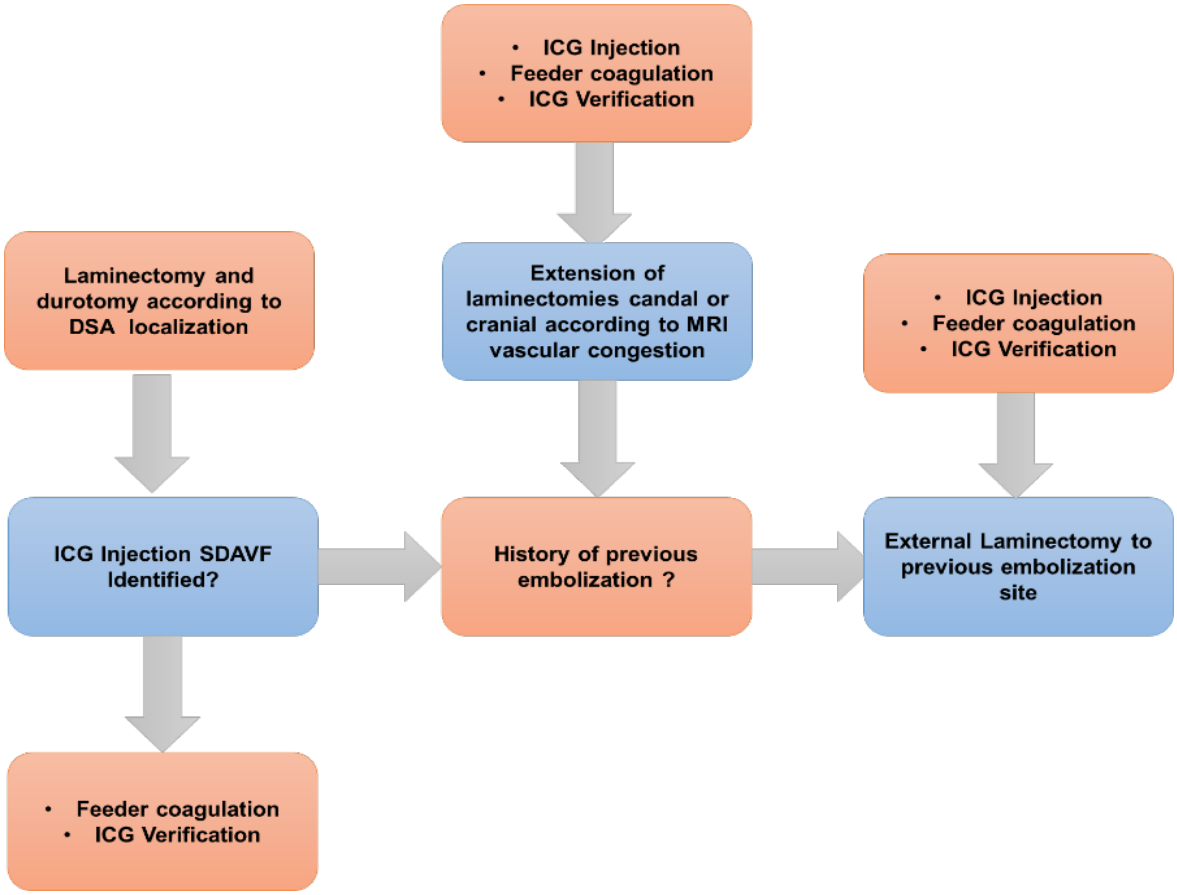

Figure 1. Exploratory surgery algorithm for SDAVF

Case 2

A man 58 years old with the baggage of serious illnesses, including continuous kidney damage, the disorder, a form of diabetes syndrome, arthritis, and ischemic heart disease, appeared with an increasing inability to walk steadily. His condition worsened following a year of using a cane, and he was denied entry without a wheelchair. The patient had been scheduled for lower fusion surgery at another clinic, where lumbar spinal stenosis had been identified as the underlying medical condition. Thoracic MRI before surgery revealed chord water retention, intravascular flow voids, and widening blood vessels. After embolization by injecting 0,6 cm3 of 26 % butyl of the substance into the right hemisphere of the brain, DSA scans revealed a D6 SDAVF. After a while in recovery, the patient was able to stroll 60 meters with the use of a walking cane and was eventually released. The patient's health deteriorated, so they underwent lumbar displacement and consolidation at a different facility. As could have been expected, he did not improve and continued to have progressive paralysis in his left leg. SDAVF remained 19 months after initial embolization. However, the fistulous blood vessels were not visible on DSA. The decision to explore surgical options for arteriovenous fistulas occurred at a discussion, including specialists from many fields. After postponing it for almost six months, the patient underwent exploratory surgery Two years and four months after the first embolization. D6 underwent laminectomy, while D5 and D7 underwent partial laminotomies. The D6 fistula on the right ventricle was active, when indocyanine green (ICG) was injected following the dural incision. After the fistula was coagulated and incised, the expanded veins showed ICG stasis, and the spinal arteries filled immediately. The patient showed no signs of neurological decline and was discharged. He improved and reported increased anesthesia in both feet during the follow-up period, but no motor returned after six months. The MRI show reduced spinal edam and normal intravascular flow, which led to a conservative treatment plan.

Case 3

A 79-year-old man presented with paralysis in his lower extremities; nine decades before admission, he had spinal surgery. The lumbar surgery worsened a sensory deficiency that already existed. Four months before his presentation, the patient started self-catheterizing because of an overactive bladder. Before the treating surgeon requested a thoracic MRI, two rounds of lumbar MRI were completed. Severe cord edema was seen on a thoracic MRI. Table 1 provides Spinal SDAVF Case 3 Summary.

Table 1. Spinal SDAVF Case 3 Summary

Category	Details
Initial Diagnosis	Left-sided SDAVF provided by small segmental branches identified via DSA.
Initial Treatment	Endovascular embolization (failed).
First Surgery	D10 laminectomy. Partial laminectomy at D11. No ICG injected due to technical issue. Right D11 foramen's exposed, tiny artery coagulated and excised. No further fistulas found.
Post-Surgery Outcome	Sent home. Returned a month later due to worsened gait and mild paraparesis (started using a walker). MRI showed exacerbation of cord edema and a steady D11 fistula on the left side. Fistula injected into right D11 artery but was invisible.
Second Procedure	Re-exploration at left D11 level. Thrombosis of all feeder routes.- Right-side D12 fistula discovered, coagulated, and incised. Expanded laminectomy at D12 (both sides).
Outcome After Second Surgery	No motor function alteration. Worsened sensory deficits; unable to walk independently. Transferred to rehab center.
Rehabilitation Outcome	Walked with splints after rehab. At 1,5-year follow-up: Acute lower-limb paraesthesia and need for self-catheterization. MRI showed closed flow gaps and diminished cord.

Case 4

A 79-year-old female with a significant medical history of thyroid cancer, type 2 diabetes, hyperlipidemia, high blood pressure, and cerebral after meningitis removal, there had been an increase in paraphrases for some time. The myositis was treated with steroids and plasmapheresis in another facility due to thoracic cord T 2 -weighted hypersensitivity. The spinal angiogram revealed no problems. Pain hardly almost decreased in the remaining 3 patients. Only one patient (mRS 0) made no complaints at all during the annual checkup they were moved to our facility for a new evaluation because she hadn't improved. Table 2 shows SDAVF diagnosis and treatment summary.

Table 2. SDAVF Diagnosis and Treatment Summary

Category	Details
Imaging Findings	Intramedullary edema and ventricular flow voids on thoracic MRI, indicative of SDAVF.
Diagnosis	L1 SDAVF on the left side confirmed by repeated spinal angiography.
Initial Treatment	Endovascular embolization (painful procedure) — unsuccessful due to cardiovascular network challenges in reaching the feeding artery.
Surgical Procedure	L1-L2 laminectomies performed. Dural opening conducted. Vein engorgement observed. No vascular anomalies found visually. ICG injection used to inspect left L1-L2 foramen. Laminectomy prolonged caudally to locate left abnormality. Fistula coagulated and severed. ICG confirmed improved vascular supply and eradication of the fistula.
Outcome	Minimal neurological alterations post-surgery. Transferred to rehabilitation. Right leg showed some strength recovery at 2-month follow-up. Left leg showed no improvement. Patient lost to follow-up afterward.

RESULTS

The right diagnosis is essential for determining and validating the existence of SDAVF. Magnetic resonance imaging (MRI) and spinal angioplasty are two common imaging procedures used to make diagnoses. These examinations assist in identifying the aberrant blood vessels and assessing the severity of the issue at hand. One of the main SDAVF treatment modalities is endovascular embolization. A catheter is inserted during this surgery and directed to the location of the fistula through the blood vessels. The aberrant blood flow is subsequently stopped and the fistula is sealed off by injecting embolic materials like glue or coils. To verify that the fistula has closed after treatment, DSA imaging may be used. On the mRS scale, none of the patients claimed a reduction of more than one grade figure 2 and table 3 depict the Pretreatment and Post-treatment of the Spinal Dural Arteriovenous Fistula.

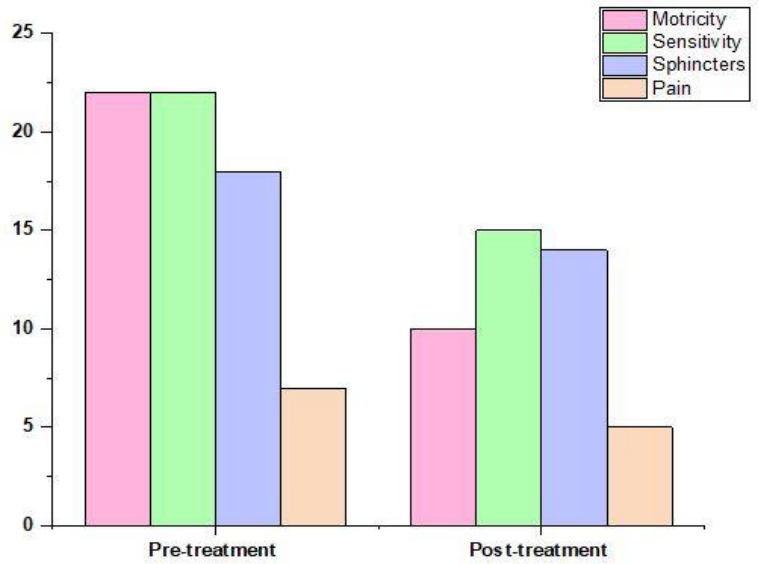

Figure 2. Pre-treatment and Post-treatment of Spinal Dural Arteriovenous Fistula

Table 3. Numerical Comparison of pre-treatment and post-treatment

Methods	Motricity	Sensitivity	Sphincters	Pain
Pre-treatment	22	22	18	7
Post-treatment	10	15	14	5

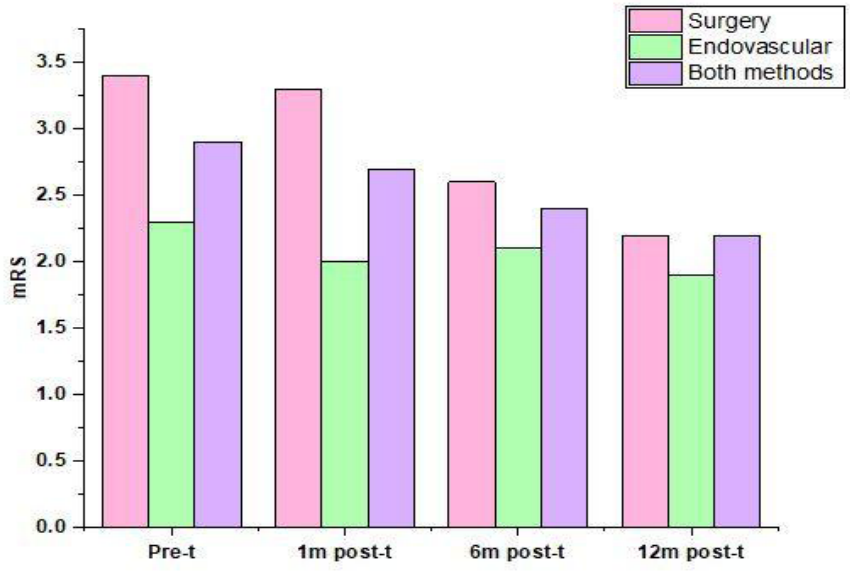

Figure 3. Neurological deficit before and after treatment

Table 4. Comparison of Neurological deficit before and after treatment			
Treatment	mRs		
	Surgery	Endovascular	Both methods
Pre-t	3,4	2,3	2,9
1m post-t	3,3	2	2,7
6m post-t	2,6	2,1	2,4

The evaluation of a patient's health status and prognosis after a specific amount of time has passed from their initial medical intervention or therapy is referred to as the outcome (Mrs) of patients at follow-up. The term "mrs" refers to the Modified Ranking Scale, a widely used tool for assessing patients' functional outcomes and level of disability, particularly those who have had a stroke. Patients with varied medical illnesses may utilize other outcomes indicators or scoring systems to evaluate patients' functional status and prediction. largely employed in the environment of stroke patients. According to the 40 patients, 8 (20 %) were lost to follow-up, and 70 % of them (asymptomatic or with minimal disability, mRS 0 or 1) did not report any negative effects on their quality-of-life figure 4 and table 5 shown outcome modified Rankin Scale (Mrs) of patients at follow-up.

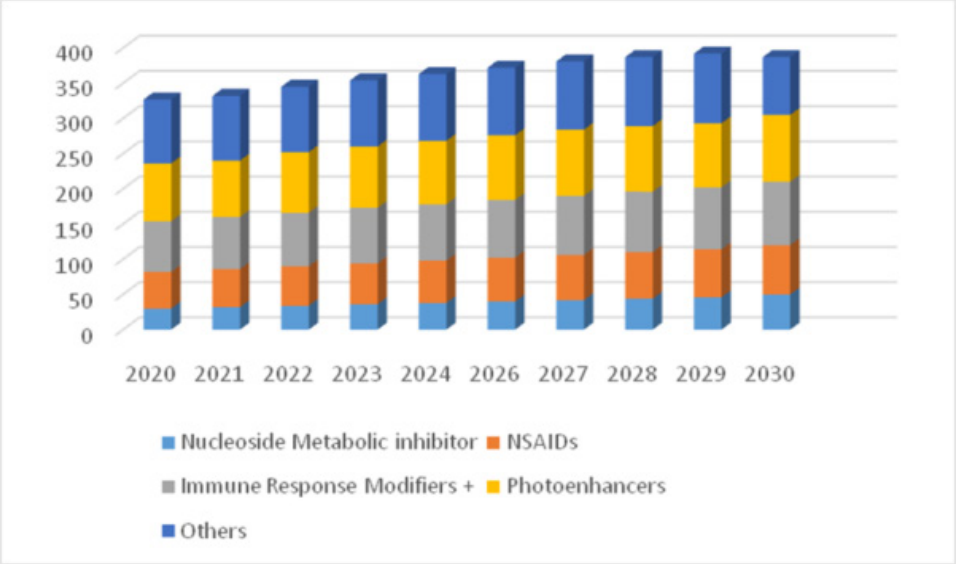

Figure 4. Outcome (mRs) of patients at follow-u

Table 5. Comparison of patients at follow-up	
mRS 0	34,7
mRS 1	39,6
mRS 2	2,8
mRS 3	2
mRS 4	7
mRS 5	1
mRS 6	3,9
Lost to follow-up	22

DISCUSSION

SDAVF is typically brought on by an improper exchange of signals between the vascular circulation and a radicular artery at the site of the dural root sleeve. The gold standard for the identification and localization of spinal stenosis is diagnostic spinal angiography. The beginning of the feeder arteries is misplaced. This finding suggests that either a late recurrence in the initial embolization. In contrast, fresh anatomizes occurred in the fistula's arterial blood source. It has been established that when the fistula is closed, the thoracic myelopathy that characterizes most patients with SDAVFs stabilizes or very slightly improves. Due to the frequent delays in diagnosis, most patients have a persistent myelopathic impairment; two of the four patients in the current sample required final SDAVF closure procedures two and five years, respectively, after SDAVF embolization.

The individuals said that during those years, their clinical conditions became worse, which was supported by their physical examination. Two of the four patients underwent lumbar spinal fusions in other facilities before the previous SDAVF closure. Surgical exploration may still be part of an SDAVF treatment strategy in some circumstances, even though continual advances in imaging technologies have made it all but unnecessary. Spinal angiography is typically used to diagnose SDAVFs, and they can be Surgery or endovascular embolization may be used for treatment. Only four patients needed surgery during the learning year, as spinal angiography is used at our clinic as the primary effort at closure throughout the diagnostic process. Studies and case series have previously described angiographically occult SDAVFs. Following bleeding and incision of the affected vessel, ICG provided intraoperative viewing of the fistula and destruction verification. In our facility, surgical SDAVF closure routinely uses ICG microscopic angiography. ICG angiography was impossible during surgical exploration on a patient one or during patient three's initial surgery due to a malfunctioning microscope. In all situations, the level that had been embolized had an active fistula, indicating that the feeding arteries had not wholly been blocked. Furthermore, on two separate occasions, the fistulous vessels' presence and location were misrepresented by DSA. There's no disease at all occurring in the subject. In another, DSA provided evidence These diseases present a more significant challenge to the surgeon, who is skilled in adhering to a precise surgical plan created from the results of preoperative imaging. Plan adaptation and fistula obliteration verification are made possible by intraoperative ICG microscopic angiography. For these particular instances, we have developed an explorative surgery method.

CONCLUSIONS

In challenging cases, training young surgeons to accommodate intraoperative plans, be mindfully flexible, and continuously monitor surgical progress will produce better results. During fistula the coagulation process, usually use intraoperative neuromonitoring and brief clips. This method was not applied to the current cohort. Blood flow in the fistula can also be monitored intraoperatively using micro-Doppler, although did not employ this method in the recent cohort. In angiographically occult, as well as angiography was incorrect in three instances. In two cases, DSA revealed an unacceptable level of SDAVF, and in one case, a side fistula and a false story. Extramural anatomizes connect the feeding vessel identified on the angiogram and the infectious ship entering the Dura. Prompt treatment of SDAVFs is necessary to prevent the development of chronic myelopathy in the thorax. The preferred imaging technique for detecting these anomalies is DSA. Occasionally, SDAVFs will be invisible on a coronary, or the angiography will misrepresent the location of the lesion. Spinal fistulas can be closed successfully and safely using ICG microscopic angiography during the exploration process.

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