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Analysis of the efficacy and factors affecting the prognosis of intracranial dissecting aneurysm treated with multi-stent overlap technique

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Abstract

Objective The study aims to identify characteristics that impact the postoperative prognosis and recurrence of intracranial dissecting aneurysms (IDA) patients treated using multi-stent overlapping techniques.

Methods Clinical data from 69 IDA patients treated with multistate-assisted spring coil embolization at the hospital between January 2017 and October 2023 were retrospectively reviewed, including clinical and imaging data gathered at admission and discharge. The prognosis was determined based on mRS grade at discharge, and the patients were divided into excellent prognosis (mRS 0–2 points) and poor prognosis (mRS 3–6 points). They were split into two groups: recurrence and no-recurrence, based on whether the patients had recurrence during surgical follow-up. The patient's clinical information and aneurysm data were compared between the two groups to better understand the efficacy of multi-stenting for IDA and to investigate the factors that influence the good or negative prognosis of multi-stenting for IDA and recurrence.

Results The prognosis was poor in 10 patients, 7 of whom died, while 59 had an excellent prognosis. Hunt-Hess classification ($\chi2 = 25.503a$, $P = < 0.01$), hospitalization days (t=-3.873, $P < 0.01$), operation time (t=-1.970, $P = 0.049$), and aneurysm height (t=-1.969, $P = 0.049$) were all significant. 62 patients were discharged with 4 postoperative recurrences and 58 without recurrences in patients treated with multiple stents, with significant differences in the largest diameter (t=-2.235, $P = 0.025$), basal length (t=-2.149, $P = 0.032$), and position(located in pica base or not) ($\chi2 = 10.955a$, $P = 0.001$). The postoperative recurrence rate was 5.8%, but 85.8% reported satisfactory neurologic function (mRS ≤ 2). The case fatality rate was 10.1%.

Conclusion Hunt-Hess grading on admission, aneurysm high, and operation time affect the prognosis of IDA, Hunt-Hess grade was an independent risk factor for prognosis. Aneurysm size, longest diameter, basal length, and location at the base of the pica affect recurrence. Located in pica base by the dissecting aneurysm is an independent risk factor for recurrence.

Keywords Intracranial dissecting aneurysm, Multiple brackets, Prognosis, Recurrence

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Intracranial dissecting aneurysms (IDA) mostly affect individuals in the middle-aged and young adult population. After the ripping and peeling off of the outer and middle membranes, the arterial artery wall bulges and spreads outward towards the blood vessels, developing along the long axis to produce a formation resembling a aneurysm [1, 2].IDA may manifest in any of the intracranial arteries, although it is more often seen in the posterior circulation, namely the vertebrobasilar system, among Asian people [3]. The prevalence of vertebrobasilar intracranial dissecting aneurysms (IDA) is estimated to be around 1 in 100,000 to 1.5 in 100,000 cases, with about 3/4 to 4/5 of these aneurysms occurring in the intracranial vertebral arteries [4]. Treating these aneurysms is more difficult due to the absence of a proper neck structure, and they are a significant cause of arachnoidal subarachnoid hemorrhage and posterior circulation stroke [5]. The distinctive shape and structure, as well as the elevated risks of hemorrhage and mortality, have prompted the promotion of assertive surgical intervention [6]. Neurosurgeons have a big problem when it comes to treating IDA via surgical and endovascular methods. Endovascular treatment has emerged as the preferred method for treating this type of aneurysm [7]. This treatment involves blocking the arteries carrying the aneurysm and restoring blood flow through various methods, with the most commonly used method being revascularization. Revascularization can be achieved through simple stent implantation, stent-assisted spring-coil embolization, or flow diverter (FD) implantation [8, 9]. According to the principles of hemodynamics and flow guidance, lowering the area of the stent mesh by several stent releases, with or without spring coil embolization, is a more successful method for eliminating dissection compared to using a single stent-assisted spring coil therapy [10]. This study retrospectively analyzes the clinical data of 69 patients with IDA who were admitted to our center from 2017 to 2023. It aims to provide a reference for the clinical treatment of IDA by summarizing the factors that influence the prognosis and recurrence of IDA after the procedure. Currently, there are limited studies on these factors in the treatment of IDA with multiple stent overlap technique.

Details and approach

Clinical materials

A total of 69 consecutive patients diagnosed with IDA were admitted to the Hospital between January 2017 and October 2023. The inclusion criteria were as follows: (1) The presence of intracranial dissecting aneurysm (IDA) confirmed by digital subtraction angiography and cranial MRI; (2) The presence of clinical symptoms such as headache, dizziness, and limb mobility disorders; (3) Treatment of the dissecting site with more than two stenting treatments combined with spring coils; (4) Patients with complete clinical data. Exclusion criteria include individuals who have experienced serious complications from the surgical technique and are not suited for endovascular therapy surgery, as well as patients and their family members who have declined surgery.The Hunt-Hess classification was performed according to the patient's primary subarachnoid hemorrhage at admission. During angiography, the location typing of IDA was differentiated according to whether it was located near the pica blood vessel, and it was divided into pica base or non-pica base.

Treatment

All patients who underwent surgery received at least two stents, and the aneurysm cavity was filled with the appropriate amount of spring coils. For patients with unruptured IDA, oral administration of dual antiplatelet agents (clopidogrel 75 mg, aspirin mg) was initiated 3 days before surgery. For patients with IDA hemorrhage, 0.5 mg of tirofiban hydrochloride was injected intravenously when the first stent was released during the operation, and 0.2 mg/h of continuous intravenous pumping was performed after surgery. Treatment was changed to dual antiplatelet drugs 24 h later. All patients continued to take clopidogrel 75 mg and aspirin 100 mg orally after surgery. After 6 months, it was changed to 100 mg aspirin for long-term use. Before operation, the whole body was heparinized with conventional dose. seldinger technique was used to insert 6 F catheter sheath through the femoral artery and to the distal end of the aneurysm bearing artery under the guidance of microguide wire. Meanwhile, the spring-coil microcatheter was sent to the dissecting aneurysm cavity under the guidance of the microguide wire. The stent was successfully released by opening and covering both ends of the lesion. Under the guidance of the stent pushing guide wire, the second stent was delivered to the distal end, then the spring ring was further filled according to the shape of the aneurysm and the location of the break, and the second stent was released inside the first stent and placed side by side. If the IDA length was too large for one stent to cover completely, the telescope technology was used to connect two scaffolds in series to ensure that the normal segments of the proximal and distal ends of the aneurysm can be covered [11]. In the process of placement, it was necessary to ensure the stability of the stent and good adhesion to the wall. The embolization status of the aneurysm should be judged according to the retention of the contrast agent, and the third stent should be placed according to the situation. In principle, the stent should be slightly larger than

the diameter of the vascular cavity, so as to achieve the effect of squeezing the interlayer of the aneurysm cavity and making the interlayer fit perfectly with the tube wall as far as possible. The stent selected during the operation was selected according to the shape of the dissecting aneurysm and the size of the vascular cavity.

Postoperative therapy evaluation and follow-up

The immediate postoperative DSA imaging evaluation utilized Raymond grading to assess the results. Grade I was assigned to cases with dense embolization, grade II indicated residue in the aneurysm neck, and grade III indicated residue in the aneurysm body. The categorization of cure and recurrence was based on the findings of the follow-up. The discharge was assessed using the Modified Rankin Scale score (mRS), which was divided into two categories: excellent prognosis (mRS 0–2 points) and poor prognosis (mRS 3–6 points).

Statistical analysis

The data were organized using Excel tools, and the statistical software SPSS 26.0 was utilized for statistical analysis. Measures that follow a normal distribution are typically represented as the mean plus or minus the standard deviation ($x \pm s$).Measurements that did not follow a normal distribution were described using the median (M) along with the 25th and 75th percentiles (P25, P75). Count data were described using the number of cases (n) along with the percentage (%). Non-normally distributed measurements were compared between groups using the Mann-Whitney U-test, while count data were compared using the Chi-square test. A statistically significant difference was indicated by a *p*-value of less than 0.05. Importance. Variables that exhibited statistically significant differences were included in a multifactor binary logistic regression analysis. Differences were deemed statistically significant when the *p*-value was less than 0.05.

Results

Surgical results and postoperative situation

A total of 69 patients underwent multi-stent-assisted spring coil embolization treatment. Immediate postoperative embolization was performed in 64 cases, whereas 5 cases had residual aneurysm in the neck area and no cases had residual aneurysm in the body. There were a total of 10 instances of perioperative complications, including 8 instances of ischemia problems and 2 instances of bleeding difficulties. The Modified Rankin Scale (mRS) score at discharge was 10, with 3–6 indicating severe disability. Out of the total score, 7 patients died either at release or within 3 days after discharge. Out of a total of 69 patients, 7 unfortunately passed away while 62 were successfully discharged.

Follow-up results

The outcomes of 62 patients were monitored for a period ranging from 3 to 25 months after their surgery. Out of these, 46 patients were discharged from the hospital after their imaging results confirmed complete embolization. At the time of telephone follow-up, 12 patients were leading a normal life. However, during the follow-up, it was discovered that 4 patients experienced a recurrence of the original aneurysm at the base of the aneurysm. Among these cases, one patient showed contrast residue in the neck of the aneurysm in the immediate postoperative imaging result.

Monofactor analysis (Tables 1, 2, 3 and 4)

Patients who received multiple stents were released from the hospital with a poor prognosis group of 10, an excellent prognosis group of 59, and 7 deaths. The study found that Hunt-Hess's classification ($\chi 2 = 25.503a$, $P = < 0.01$), days of hospitalization ($t = -3.873$, $P < 0.01$), operative time ($t = -1.970$, $P = 0.0.049$), and aneurysm high ($t = -1.969$, $P = 0.049$) were statistically significant factors.Due to the fact that some patients with very poor prognosis gave up treatment and were discharged shortly after admission, the length of stay between the two groups was different, but it was not suitable for judging the prognosis in this study.A total of 62 patients were released from the hospital. Among these patients, 4 experienced postoperative recurrences while the remaining 58 did not. The patients who received multiple stents showed substantial results in terms of the longest diameter ($t = -2.235$, $P = 0.025$), basal length ($t = -2.149$, $P = 0.032$), and staging ($\chi 2 = 10.955a$, $P = 0.001$). The rate of recurrence after surgery was 5.8%, but the rate of satisfactory neurologic function ($mRS < 2$) after surgery was 85.8%.

Multifactorial analysis (Tables 5 and 6)

The results of incorporating the various outcomes from the single-factor grading into the multifactorial regression analysis revealed that the Hunt-Hess grading was identified as an autonomous risk factor for prognosis, while the involvement of the base of the pica was recognized as an autonomous risk factor for recurrence.

Discussion

At our center, we mostly utilize double stents and a limited number of triple stents in conjunction with spring coils to aid in embolization therapy. Since dissecting aneurysm has no obvious neck structure, endovascular treatment is often used. Previous clinical experience and research results have shown that the recurrence rate of dissecting aneurysm with simple spring coil is higher than that of cystic aneurysm [12], so stent-assisted spring coil embolization is more commonly used to treat this

Table 1 Relationship between basic patient information and prognosis

Groups	excellent prognosis group	poor prognosis group	*p*-value
Numbers	*N* = 59,n(%)	*N* = 10,n(%)	
Age(¯x ± s, years)	57 ± 9.7	60 ± 12.3	0.377
Sexes			
male	38(64.4)	5(50)	0.385
Female	21(35.6)	5(50)	
Complication			
high blood pressure	28(47.5)	5(50.0)	0.882
Diabetes	10(16.9)	2(20.0)	0.814
hyperlipidemia	10(16.9)	2(20.0)	0.814
Smoking			
Yes	2(42.4)	2(20.0)	0.180
no	34(35.9)	8(80.0)	
Hunt-Hess grade			
0–2	55(93.2)	3(30.0)	<0.001
3–5	4(6.8)	7(70.0)	
Surgery time(min)	180(120.0,200.0)	210(180.0,307.5)	0.049
Days in hospital(d)	20(15.0,27.0)	4(3.0,10.25)	<0.001

with $P < 0.05$ indicating that the difference was statistically significant

disease [13]. Common stent types include braided stent and laser engraving stent. Braided stent has a certain blood flow guiding effect, and the distribution of metal coverage area can be flexibly controlled through push-pull operation. However, laser engraving stent has low metal coverage and is not suitable as the best choice for IDA treatment.However, the base of many dissected aneurysms is long and their shape is huge, and a single stent is not enough to cover the entire aneurysm structure, some stents are not enough to support, or the blood flow guidance device of a single stent is weak. For all these IDA parts, multiple stents are often overlapped, which on the one hand can improve the metal coverage on the surface of the diseased vascular wall. Minimize the incident blood flow in the aneurysm lumen; On the other hand, in order to make the endovascular stent fully cover the diseased blood vessels, reduce the leakage of the bearing artery wall rupture, so the use of multiple brackets is necessary. On this basis, with the emergence of blood flow guidance devices, blood flow guidance devices have been gradually applied in the intravascular therapy of IDA [14].The specific stents we employ include the LVIS stent, Enterprise stent, Leo stent, and dense mesh stent. Based on various inter-stent features, the combination of numerous stents with spring coils might enhance the stability of the stent, modify the hemodynamics within the aneurysm, and decrease the time it takes for an aneurysm to close [15–17]. A commonly used stent combination is the LVIS + Enterprise double stent-assisted embolization in this study. The advantage of this combination is that the Enterprise stent, being a carved stent, does not protrude into the aneurysm like the LVIS braided stent does. This allows for smooth filling of the spring coils into the aneurysm, ensuring the formation of intra-aneurysmal thrombus quickly. Additionally, the LVIS stent provides a higher density of braiding. These two stents simultaneously, LVIS offers a greater braiding density. The combination of these two stents exhibits a greater metal density and superior stent adhesion to the wall, making the LVIS + Enterpeise combination theoretically superior [18–21]. Additionally, other stent combinations also demonstrated positive outcomes in the treatment of IDA in this study. On the other hand, the various stents guarantee that there is no overlapping of the holes in the stent mesh, which ensures the effectiveness of the treatment. Based on the special physiological and pathological characteristics of IDA, all the multi-stent-assisted spring coil embolization in our center has achieved a good therapeutic effect, which is similar to the results of previous studies, and can be used as one of the best treatment methods for IDA [22, 23].

The occurrence of IDA is a result of multiple factors. In contrast to typical aneurysms, IDA exhibits distinct anatomical and clinical characteristics, more intricate hemodynamics, and a scarcity of prior research. In our study, we found that several factors were associated with the risk of recurrence of IDA. These factors include the admission Hunt-Hess classification, the longest diameter of the aneurysm, the basal length, and the location of the IDA (specifically, whether it is dissecting at the base of the pica or the

Table 2 Relationship between morphology and prognosis of dissecting aneurysms

Groups	Excellent prognosis group	poor prognosis group	*p*-value
Numbers	*N*=59,n(%)	*N*=10,n(%)	
Size(mm)			
〈10	38 (66.1)	7 (70.0)	0.809
〉10	21 (33.9)	3 (30.0)	
Points			
Right	27 (45.8)	4 (40.0)	0.096
left	31 (52.5)	4 (40.0)	
basilar artery	1 (1.7)	2 (20.0)	
Morphological			
cystic lateralization	46 (78.0)	7 (70.0)	0.675
Irregular shuttlecock	7 (11.9)	2 (20.0)	
Shuttlecock	4 (6.8)	1 (10.0)	
beadlike	2 (3.4)	0 (0.0)	
Longest diameter(mm)	8.0 (5.6,12.4)	9.4 (4.6,10.7)	0.946
Substrate length(mm)	7.8 (5.0,11.4)	9.4 (4.9,10.7)	0.811
High(mm)	3.5 (2.6,5.8)	5.3 (4.1,8.3)	0.049
Length/high	1.0 (0.3,2.2)	0.9 (0.2,2.6)	0.195
Aneurysm-carrying artery stenosis			
yes	18 (30.5)	3 (30.0)	0.974
no	41 (69.5)	7 (70.0)	
Location typing			
Non-Pica base	50 (84.7)	7 (70.0)	0.225
Pica base	9 (15.3)	3 (30.0)	
Bracket type			
Enterprise+Lvis	29(42.9)	5(50.0)	0.638
Lvis*2	15(25.4)	2(20.0)	
Enterprise*2	5(8.5)	1(10.0)	
Lvis*2+Enterpris	1(1.7)	1(10.0)	
Lvis+Leo	6(10.2)	0(0.0)	
FD*2	3(5.1)	1(10.0)	

with $P < 0.05$ indicating that the difference was statistically significant

Table 3 Relationship between basic patient information and recurrence

Groups	Non-recurrence group	recurrence group	*p*-value
Numbers	N=58,n(%)	N=4,n(%)	
Age($\bar{x} \pm s$, years)	57.0±10.0	62.8±5.0	0.255
Sexes			
male	37 (63.8)	2 (50.0)	0.581
female	21 (36.2)	2 (50.0)	
Complication			
high blood pressure	27 (49.6)	3 (75.0)	0.271
Diabetes	6 (10.3)	1 (25.0)	0.370
hyperlipidemia	9 (15.5)	1 (25.0)	0.618
Smoking			
Yes	23 (39.7)	2 (50.0)	0.683
no	35 (60.3)	2 (50.0)	
Hunt-Hess grade			
0-2	54 (93.1)	3 (75.0)	0.198
3-5	4 (6.9)	1 (25.0)	
Admission GCS score			
3-8	2 (3.4)	0 (0.0)	0.384
9-12	4 (6.9)	1 (25.0)	
13-15	52 (89.7)	3 (75.0)	
Surgery time(min)	165.0(127.5,180.0)	180.0(120.0,240.0)	0.549
Days in hospital(d)	25.0 (18.3，28.8)	19.5(15.0，27.0)	0.374

with $P < 0.05$ indicating that the difference was statistically significant

base of the non-pica). We also found that involvement of the base of the pica is an independent risk factor for IDA recurrence, which is consistent with findings from previous studies [24]. Bleeding from a ruptured aneurysm is a frequent complication, and ruptured arteries have a higher likelihood of recurring and not healing compared to aneurysms that have not ruptured. When analyzing the shape of an aneurysm, factors such as its longest diameter, the length of its base, and its location have an impact on the likelihood of recurrence after treatment. Greater aneurysms are more prone to having spring coils that are loose or displaced and exhibit more intricate blood flow patterns. The length of the aneurysm base determines the necessary stent length and the density of the stent required. The base of an intracranial dissecting aneurysm (IDA) is typically longer than that of a typical aneurysm. Using a single stent to fully cover the aneurysm base is inadequate in meeting the requirement of slowing down the blood flow due to the expansion and contraction of the stent. Utilizing several stents can provide as an effective resolution to this issue. Nevertheless, there are still instances of IDA recurrences. In this particular study, the rate of recurrence was 6.5% (4/62), all of which occurred in the base of the original aneurysm. Out of the four dissecting aneurysms that occurred repeatedly, three were found in the base of the pica. This is believed to be partially due to hemodynamic alterations [25]. Reconstructive procedures that aim to retain the pica typically involve partially opening the aneurysmal sac located at the base of the pica. This is done to ensure sufficient blood flow into the pica. However, this procedure carries a high risk of aneurysmal recanalization for the patient. Consequently, aneurysms that affect the posterior inferior cerebellar artery (PICA) have posed a challenging issue in the treatment of aneurysms [26]. There is a suggestion that if blood continues to flow into the pica, there is a chance of recurrence. This is why the pica located at the base of the IDA is more likely to cause recurrence. While it is important

Table 4 Relationship between morphology and recurrence of dissecting aneurysms

Groups	Non-recurrence group	recurrence group	*p*-value
Numbers	*N* = 58,n(%)	*N* = 4,n(%)	
Size(mm)			
<10	41(70.7)	0(0.0)	0.004
>10	17(29.3)	4(100.0)	
Points			
Right	26(44.8)	2(50.0)	1.000
left	30(51.7)	2(50.0)	
basilar artery	2(3.4)	0(0.0)	
Morphological			
cystic lateralization	2(50.0)	46(79.3)	0.207
Irregular shuttlecock	2(50.0)	5(8.6)	
Shuttlecock	0(0.0)	5(8.6)	
beadlike	0(0.0)	2(3.4)	
Longest diameter(mm)	8.0(5.0,11.6)	12.4(10.9,20.0)	0.025
Substrate length(mm)	7.7(4.9,11.1)	11.7(10.1,20.0)	0.032
High(mm)	3.5(2.6,5.9)	3.3(2.4,10.8)	0.819
Length/high	1.1(0.4,2.2)	0.3(0.1,3.7)	0.252
Aneurysm-carrying artery stenosis			
yes	17(29.3)	1(25.0)	0.854
no	41(70.7)	3(75.0)	
Location typing			
Non-Pica base	41(70.7)	0(0.00)	0.001
Pica base	17(29.3)	4(40.0)	
Bracket type			
Enterprise + Lvis	29(50.0)	2(50.0)	0.865
Lvis*2	15(25.9)	1(25.0)	
Enterprise*2	5(8.1)	0(0.0)	
Lvis*2 + Enterpris	1(1.7)	0(0.0)	
Lvis + Leo	5(8.1)	1(25.0)	
FD*2	3(5.2)	0(0.0)	

with $P < 0.05$ indicating that the difference was statistically significant

Table 5 Multifactorial analysis affecting prognosis

Groups	Coefficioent	SE	*p*-value	OR	95%CI
Surgery time	−0.004	0.006	0.515	0.996	−0.195 ~ 0.259
Days in hospital	0.013	0.036	0.719	1.013	−0.112 ~ 8.998
High	−0.285	0.169	0.091	0.752	−11.525 ~ 0.981
Hunt-hHess garde	3.458	1.020	0.001	31.760	2.139 ~ 85.673

with $P < 0.05$ indicating that the difference was statistically significant

Table 6 Multifactorial analysis of recurrence

Groups	Coefficioent	SE	*p*-value	OR	95%CI
Substrate length	0.198	0.471	0.674	1.220	−17.338 ~ 50.290
Longest diameter	−0.450	0.501	0.807	0.369	−60.207 ~ 15.781
Location typing	2.925	1.335	0.028	4.799	−17.438 ~ 257.011

with $P < 0.05$ indicating that the difference was statistically significant

to keep the pica open, there is still a possibility that some blood flow may enter the aneurysm. If the blood flow is maintained at a certain rate, this could lead to recurrence. Further hemodynamic studies are needed to understand this better in patients with recurrent IDA. Furthermore, the benefits of employing multiple stent-assisted embolization for IDA include a direct correlation between hemodynamic enhancement and the quantity of overlapping stents. Furthermore, stents serve to impede the compression, collapse, rupture, and development of spring coils and aneurysms

[27, 28]. Consequently, there is a stronger inclination towards utilizing numerous stents in conjunction with spring coils or thick mesh stents for the purpose of reconstructing IDA. The recurrence rate in this study was 6.5%, which is significantly lower than the previously reported rates of 10.9% and 13% [29]. This indicates that using multiple stent-assisted embolization is highly beneficial for treating dissecting aneurysms, particularly when dealing with different types of aneurysms (coxal versus wide-base) [30]. In our study, we found that the immediate postoperative embolization rate was approximately 92.8% (64/69). Out of these, 5 cases had partial contrast residue in the aneurysm, while 64 cases had complete postoperative embolization. In contrast to using only a stent and spring coil for dense embolization to achieve a complete embolization rate, the high-metallic-density stent has a relatively slow blood path-directing effect. The utilization of multistenting in cases of residual aneurysm neck should not be considered a contributing factor to postoperative recurrence, as the blood flow to the aneurysm neck gradually diminishes over time until the aneurysm neck site is fully occluded [30].

This study also identified Hunt-Hess grading, operation time, and IDA height at admission as characteristics that influenced patients' prognosis upon release. The patients were categorized into two groups based on the Hunt-Hess grading system upon admission. The less symptomatic group consisted of patients with grades 0–2, whereas the more symptomatic group consisted of patients with grades 3–5 [31]. The findings indicated a negative correlation between the grading level and the prognosis, suggesting a potential underlying mechanism. The escalation of Hunt-Hess grading results in heightened risks of preoperative cerebral ischemia, severe nerve cell damage caused by hemorrhage, increased likelihood of aneurysm rebleeding, and elevated risk of cerebral vasospasm. Even after reconstructing the aneurysm-carrying arteries and embolizing hemorrhagic aneurysms, some irreversible damage may persist, potentially leading to an unfavorable prognosis [32].Hunt-Hess increased scores are typically linked to greater and more extensive IDA morphology. Consequently, these IDA are more prone to causing subarachnoid hemorrhage and necessitating longer surgical procedures, which ultimately impacts the prognosis. Furthermore, each stent used in this study was employed according to its intended purpose, and there was no notable association observed between the utilization of different combinations of stents and the prognosis or recurrence of patients with IDA.

Conclusion

To summarize, the findings of this study indicate that the prognosis is influenced by several factors, including the time of procedure,, IDA height, and Hunt-Hess grading. Specifically, Hunt-Hess grading was identified as an independent risk factor that affects IDA in patients undergoing double stenting. Furthermore, the study found that the prognosis worsens as the Hunt-Hess grading increases. Basal length, longest diameter, and typology are characteristics that increase the likelihood of recurrence. Specifically, the type of intercalated aneurysm that affects the basal region of the pica is an independent risk factor for recurrence after double stenting for IDA. Furthermore, the use of several stents for the treatment of IDA yields superior outcomes in terms of reducing the likelihood of IDA recurring and enhancing the overall prognosis. Nevertheless, the expanded metal covering resulting from multi-stenting also heightens the likelihood of branch artery occlusion, which in turn leads to ischemic episodes.

Limitation

However, this study has limitations due to its single-center design and small sample size. Additionally, there is no analysis of the morphology and hemodynamics of IDA, and there is a lack of numerical visualization to demonstrate the therapeutic characteristics of multiple stents for IDA with different morphology and location. Furthermore, it is necessary to further investigate whether there are any differences between the two treatments, namely the combination of multiple stents and dense mesh stents with high metal coverage, and what these differences entail. Additional research is required. Thus, it is necessary to conduct bigger sample sizes and additional follow-up studies in order to validate the dependability of multistent therapy.

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Authors' contributions
Lixiaolin wrote the main manuscript text,Huhuojun reviewed the manuscript. Other authors have made contributions in writing, revision, consultation and editing.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
This study was approved (or granted exemption) by the ethics committee of Medical Ethics Committee of Yichang Central People's Hospital (approval no.$_{2024-133-01}$). We certify that the study was performed in accordance with the 1964 declaration of HELSINKI and later amendments.

Consent for publication
Not applicable

Competing interests
The authors declare no competing interests.

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