Comparison of efficacy and safety of neuroendoscopic surgery and minimally invasive puncture surgery in the treatment of spontaneous cerebral hemorrhage: A meta-analysis

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Abstract

Objective: To compare the efficacy and safety of neuroendoscopic surgery and minimally invasive puncture surgery in the treatment of spontaneous cerebral hemorrhage. *Methods:* The English databases, including PubMed, OVID, EMBASE, Cochrane Library, and the Chinese databases, such as CNKI, Wanfang and Weipu, were computer searched to collect the relevant literature on the treatment of spontaneous cerebral hemorrhage by neuroendoscopic surgery and minimally invasive puncture surgery. The included literature was meta-analyzed using Stata 17.0 software. *Results:* A total of 10 articles were included in the study. There were 344 patients in the neuroendoscopy group and 419 patients in the minimally invasive puncture group. Compared with the minimally invasive puncture group, the clearance rate of postoperative hematoma in the neuroendoscopy group was higher (MD = 19.71; 95% CI 4.84-34.57, Z = 2.60, P = 0.01 < 0.05), the amount of hematoma cleared was higher (MD = 16.5; 95% CI 5.95-27.04, Z = 3.07, P = 0.001 < 0.05), mRS score was lower (MD = -0.49; 95% CI -0.76 to -0.21, Z = -3.42, P = 0.001 < 0.05); GCS score was higher (MD = 0.74; 95% CI 0.05-1.43, Z = 2.09, P = 0.04 < 0.05). However, the operation time was longer (MD = 51.44; 95% CI 37.44-65.44, Z = 7.20, P = 0.0001 < 0.05) of patients in the neuroendoscopy group than those in the control group. *Conclusion:* Neuroendoscopic surgery is superior to minimally invasive puncture surgery in the treatment of spontaneous intracerebral hemorrhage in hematoma clearance and clearance rate, postoperative recovery, and postoperative consciousness recovery. Neuroendoscopic surgery has better efficacy and safety.

Keywords: Spontaneous cerebral hemorrhage, neuroendoscopic surgery, minimally invasive puncture surgery, meta-analysis

INTRODUCTION

Spontaneous intracerebral hemorrhage (sICH) is a type of stroke that accounts for about 20% of all strokes.[1] The mortality rate of patients is as high as 40%, and 60-80% of patients will remain disabled. It is a devastating cerebrovascular disease with high mortality.[2,3] In recent years, the incidence rate of spontaneous cerebral hemorrhage has also increased with the aggravation of the ageing population.[4,5] And compared with young patients, cerebral hemorrhage in elderly patients is often accompanied by other diseases, leading to more complicated treatment.[6] Therefore, the choice of the best treatment method is crucial for the final efficacy.

At present, there are many ways to treat sICH, such as traditional craniotomy, puncture and aspiration and endoscopic technology.[7] As an open operation, craniotomy can clear hematoma well, but it also increases the risk of brain tissue injury, which may offset the beneficial effects of surgery, especially in the case of deep soft tissue hematoma of the brain.[8] Therefore, minimally invasive puncture surgery (MIPS) has been introduced to reduce surgical trauma by removing hematoma in patients with cerebral hemorrhage. This method is less invasive but carries a risk of re-bleeding or hematoma expansion.[4,9] Subsequently, endoscopic surgery (ES) has also been widely used in the treatment of cerebral hemorrhage[10], and the removal of

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hematoma under an endoscope can significantly reduce the occurrence of brain tissue damage.[11] When MIPS and mild hypothermia technology are used to remove hematoma, it can reduce the damage of hematoma to surrounding brain tissue, effectively alleviate inflammatory reaction, reduce brain tissue damage, and improve brain function.[12] Although the application of neuroendoscopy in the treatment of spontaneous intracerebral hemorrhage has gradually increased in recent years, the efficacy and safety of neuroendoscopy compared with minimally invasive puncture are still controversial. Therefore, in this study, we adopted the method of evidence-based medicine to extract the relevant outcome indicators. We conducted a Meta-analysis of the articles published in China and abroad on the efficacy and safety of neuroendoscopic surgery and minimally invasive puncture surgery in the treatment of spontaneous intracerebral hemorrhage from January 30, 2024, to provide theoretical support for the efficacy and safety of clinical treatment of spontaneous intracerebral hemorrhage.

METHODS

Literature search strategy

The computer searched the English databases, including PubMed, OVID, EMBASE, Cochrane Library, and the Chinese databases, such as CNKI, Wanfang and Weipu, for the relevant literature on the comparison of neuroendoscopic surgery and minimally invasive puncture surgery for spontaneous intracerebral hemorrhage. The language range of the search was limited to Chinese and English. The literature was updated until January 30, 2024. The keywords included "neuroendoscopic surgery", "endoscopic surgery", "minimally invasive pulse surgery", "spontaneous cerebellar hemorrhage", "cerebellar hemorrhage", and others.

Inclusion and exclusion criteria

Inclusion criteria were: (1) Population: Patients diagnosed with spontaneous cerebral hemorrhage according to the diagnostic criteria of the Chinese Guideline for the Diagnosis and Treatment of Cerebral Hemorrhage, but not limited to nationality and course of disease; (2) Intervention and comparison: The experimental group received ES, and the control group received MIPS for sICH; (3) Outcome: Safety and effectiveness (hematoma clearance rate, hematoma clearance rate, postoperative hematoma, postoperative complications, operation time, hospital stay, mRS, postoperative GCS score) and other outcome indicators of the two treatment schemes; (4) Study design: Literature types included randomized controlled studies and non-randomized controlled studies.

Exclusion criteria were: (1) There was only one surgical method in the study and no comparison was made; (2) The patient had cerebral hemorrhage caused by trauma, aneurysm, hemangioma, and other reasons; (3) Important data was missing or could not be extracted; (4) Repeat published literature.

Data extraction and document quality evaluation

Two researchers screened the literature according to the inclusion criteria and exclusion criteria. After reading the full text of the included literature, they extracted the general data (Table 1), such as the author, the year of publication, the average age of the patient, the volume of preoperative hematoma, *et al*. and the outcome index data. In case of dispute, the third researcher participated in the decision process. Since most of the literature included in this paper were case-control studies and cohort studies, the Newcastle-Ottawa scale (NOS) was used to evaluate the quality of the literatures.

Statistical methods

Combined meta-analysis and publication offset evaluation were performed using Stata 17.0 software. The effects of categorical variables were described by relative risk (RR) and *95% CI*, while continuous variables were described by mean difference (MD) and *95% CI*. I^2 test were used to test the heterogeneity of the included literature. If $I^2 <50\%$, there was no statistical difference in the heterogeneity of the included literature. A fixed effect model was used. Otherwise, there was a statistical difference in the heterogeneity of the included literature. A random effect model was used, and the source of heterogeneity was analyzed. Egger's test was used for risk bias assessment. $P < 0.05$ was considered that the combined effect quantity MD or RR was statistically significant.

RESULTS

Literature retrieval process

A total of 341 relevant literature were retrieved

Table 1: Basic characteristics of included literature

Included literature	Research type	Number of cases (cases)		Average age (years)		Sex ratio (male/female)		Hematoma volume (mL)		Onset to operation (h)		Admission GCS score (score)		Hematoma area	Outcome measures
		ES	MIPS	ES	MIPS	ES	MIPS	ES	MIPS	ES	MIPS	ES	MIPS		
Cai 2017[13]	Retrospective analysis	20	22	59.6± 10.1	58.7± 12.4	11/9	13/9	51.7± 19.6	44.3± 18.0	/	/	7.6± 2.7	8.3± 2.0	Supratentorial chamber	1,3,4,8
Cai 2022[11]	Retrospective analysis	40	42	57.7± 10.1	54.9± 10.5	16/24	9/33	43.7± 19.1	46.5± 20.1	/	/	9.1± 2.5	9.5± 2.3	Supratentorial chamber	1,2,8
Cho 2006[15]	Retrospective analysis	30	30	56.7± 8.7	56.6± 9.0	11/19	10/20	55.5± 23.3	32.2± 15.3	/	/	9.3± 1.2	10.1± 1.5	Basal ganglia	1,2,3,4, 5,6,8
Fu 2018[16]	Retrospective analysis	61	56	61.6± 9.2	65.6± 8.8	30/31	25/31	49.8± 11.3	45.4± 15.6	9.1± 3.1	10.2± 3.5	8.0± 2.9	8.4± 3.1	Basal ganglia	1,4,5,
Goyal 2019[17]	Retrospective analysis	18	54	51±11	51±11	5/13	14/40	39.4± 7.1	32.9± 6.4	/	/	/	/	Basal ganglia	2,4,6,7
Li 2017[18]	Retrospective analysis	58	54	61.8± 9.9	59.7± 7.5	25/33	25/29	64.3± 17.2	63.1± 15.8	/	/	8.6± 3.0	8.4± 2.9	Basal ganglia	1,2,3,4, 6,7
Li 2018[19]	Retrospective analysis	25	23	61.8± 6.7	62.5± 7.3	16/9	13/10	15.9± 3.5	15.5± 3.6	/	/	11.0± 3.0	11.6± 2.9	cerebellum	1,2,3,4, 5,7
Tang 2018[20]	Retrospective analysis	42	40	65.4± 6.8	67.6± 7.1	25/17	21/19	43.1± 10.6	44.8± 9.2	3.8± 2.8	3.5± 2.3	>8,14 cases 6-8,28 cases	>8,10 cases 6-8,30 cases	Basal ganglia	1,2,4,6,7
Xiao 2020[21]	Retrospective analysis	30	78	61.3± 12.4	62.5± 12.3	16/14	40/38	43.1± 4.3	41.7± 4.4	/	/	8.23± 2.23	8.22± 2.31	Supratentorial chamber	1,4,5,6,8
Zhang 2017[22]	Retrospective analysis	20	20	55.1± 8.2	53.6± 10.2	15/5	13/7	61.5± 26.2	66.8± 23.4	/	/	7.2± 2.3	7.2± 1.9	Basal ganglia	1,4,6,7,8

Notes: (1) Endoscopic surgery (ES); Minimally invasive puncture surgery (MIPs). (2) "/" represents missing data. (3) Outcome measures: 1: Hematoma clearance rate 3 days after operation; 2: Hematoma clearance (mL); 3: Postoperative hematoma (mL); 4: Postoperative complications; 5: Operation time; 6: Hospital stay; 7: mRS (modified Rankin scale) score; 8: Postoperative GCS (Glasgow Coma Scale).

from databases, including 308 in English and 33 in Chinese. A total of 241 literature were obtained after removing duplicate literature. 82 remaining literature were obtained after reading the titles and abstracts of the literature. After receiving the full text of 82 literature, re-screening was conducted to obtain 15 literature that involved relevant systematic reviews, reviews, and animal experiments. After carefully reading the full text, the literature data were examined. Finally, 10 studies were included, and other 5 literature were excluded due to incomplete data or unable to extract data, as shown in Figure 1.

Literature quality evaluation

This paper evaluated the bias risk of the included literature according to the NOS scale. The total score of the cohort selection was 4, the total score of the comparability of the cohort was 3, the total score of the result analysis was 3, and the total score was 10. Among the 10 articles we included, 2 articles had a total score of 9[14,1], 2 articles had a total score of 8[13,15], 3 articles had a total score of 7[16,18,21], and 3 articles had a total score of 6.[19,20,22] The total scores were all larger than 5. Therefore, the quality of the 10 articles included was relatively high, as shown in Table 2.

Meta analysis of clinical results

Comparison of postoperative hematoma clearance rate of patients

A total of 9 articles[13-16,18-22] reported the comparison of hematoma clearance rate between neuroendoscopic surgery and MIPS in the treatment of sICH. The heterogeneity analysis found that I^2 = *99.08%*, with high heterogeneity. Through the analysis of the source

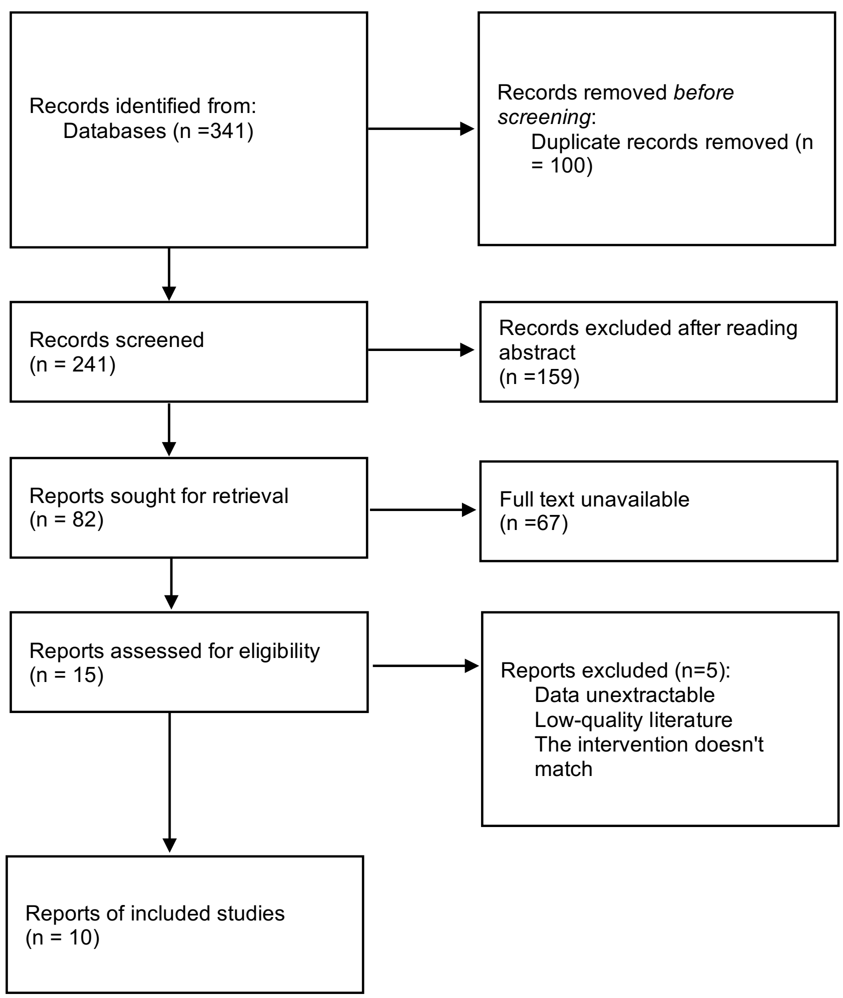

Figure 1. Flow chart of the inclusion process of literature

Table 2: NOS quality evaluation

Included literature	Queue selection (points)	Comparability (points)	Results (points)	Total (points)
Cai 2017[13]	4	1	3	8
Cai 2022[14]	4	2	3	9
Cho 2006[15]	4	1	3	8
Fu 2018[16]	3	2	2	7
Goyal 2019[17]	4	2	3	9
Li 2017[18]	3	1	3	7
Li 2018[19]	3	2	2	6
Tang 2018[20]	3	1	2	6
Xiao 2020[21]	3	1	3	7
Zhang 2017[22]	3	1	2	6

NOS: Newcastle-Ottawa scale

of heterogeneity, it was found that it might be caused by the difference in the operator's proficiency and the hematoma measurement method. Therefore, a random effect model was used to conduct a combined analysis of the effects. The results indicated that the hematoma clearance rate of neuroendoscopic surgery was better than that of MIPS (MD = 19.71; 95% CI 4.84-34.57, Z = 2.60, $P = 0.01 < 0.05$), and the difference was statistically significant (Figure 2).

Comparison of hematoma clearance volume after operation

A total of 6 articles[14,15,17-20] reported the comparison of hematoma clearance in the treatment of sICH by the two methods. The heterogeneity analysis found that $I^2 = 98.25\%$, with high heterogeneity. After the examination of the source of heterogeneity, it was found that the hematoma clearance in neuroendoscopic surgery was more than that in MIPS (MD = 16.5; 95% CI: 5.95-27.04, Z = 3.07, P = 0.001 < 0.05), The difference was statistically significant (Figure 3).

Comparison of postoperative hematoma of patients

A total of 4[13,15,18,19] articles reported the comparison of two methods for the treatment of postoperative hematoma of a sICH. The heterogeneity analysis found that $I^2 = 97.31\%$, with high heterogeneity. After subgroup analysis, it was found that $P = 0.001$. The heterogeneity source analysis was the study of Cai *et al*.[13] After removing this study, it was found that $I^2 = 7.18\% < 50\%$, and the fixed

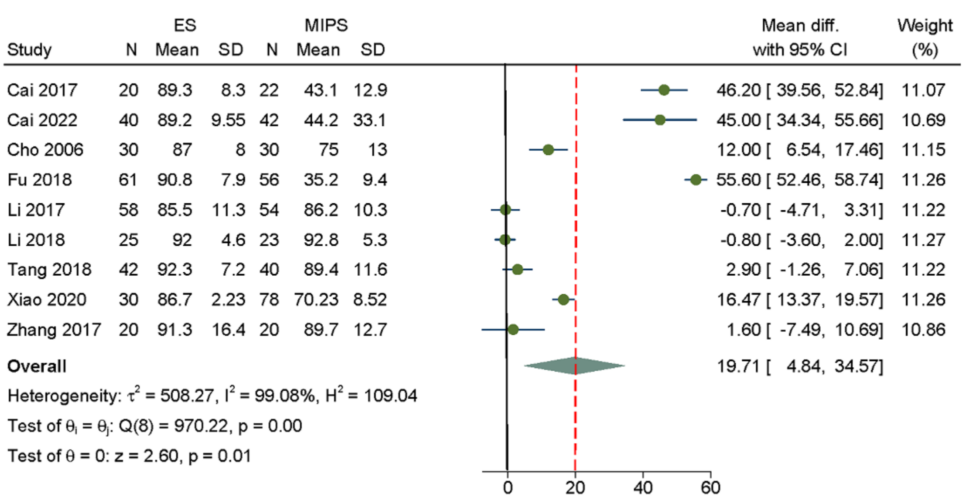

Figure 2. Comparison of hematoma clearance rate between neuroendoscopic surgery and minimally invasive puncture surgery for spontaneous intracerebral hemorrhage

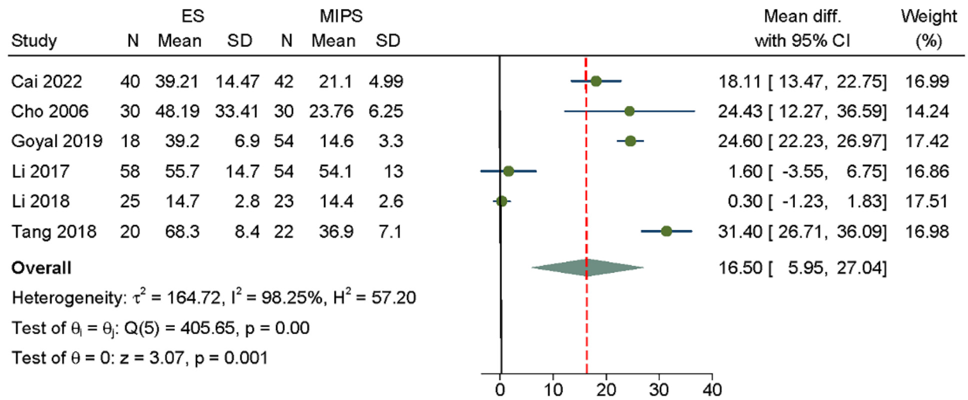

Figure 3. Comparison of hematoma clearance between neuroendoscopic surgery and minimally invasive puncture surgery for spontaneous intracerebral hemorrhage

effect model was used for the combined analysis of effect quantities. The results demonstrated no significant difference between the postoperative hematoma of neuroendoscopic surgery and MIPS (MD = -0.14; 95% CI -1.16-0.89, Z = 1.60, *P = 0.45 > 0.05*), and the difference was not statistically significant (Figure 4).

Comparison of postoperative complications of patients

A total of 9 articles[13,15-22] reported the comparison of the two methods for the treatment of postoperative hematoma of sICH. The heterogeneity analysis found that $I^2 = 63.68\%$, and the heterogeneity among the included literature was moderate. The combined analysis of the effects by the random effect model found that the postoperative complications of neuroendoscopic surgery and MIPS were not significant (RR = -0.44; 95% CI -0.97-0.09, Z = -1.63, *P = 0.10 > 0.05*), The difference was not statistically significant (Figure 5).

Comparison of operation time of two methods

A total of 4 articles[15,16,19,21] reported the comparison of the operation time of the two methods for the treatment of sICH. The heterogeneity analysis found that $I^2 = 92.33\%$, and there was high

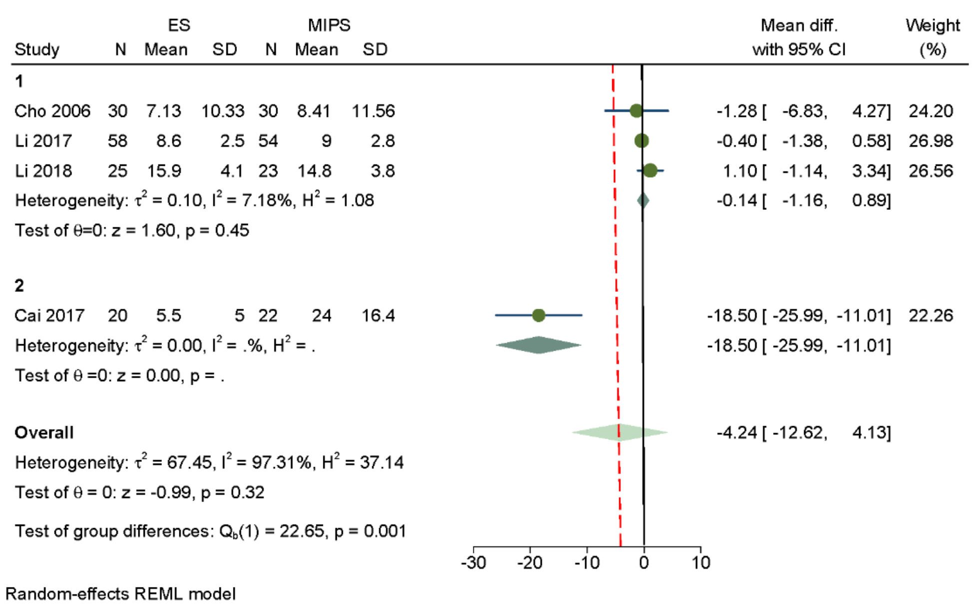

Figure 4. Comparison of neuroendoscopic surgery and minimally invasive puncture surgery in the treatment of hematoma after spontaneous intracerebral hemorrhage

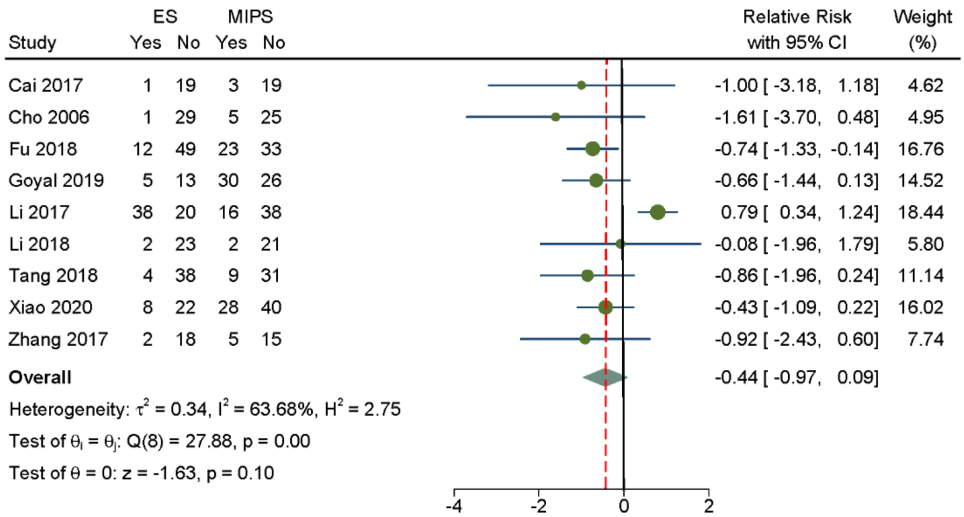

Figure 5. Comparison of postoperative complications of neuroendoscopic surgery and minimally invasive puncture surgery for spontaneous intracerebral hemorrhage

heterogeneity among the included literature. The analysis of heterogeneity sources found that it may be caused by the difference in the surgical proficiency of the surgical operators and the difference in the recording standard of the operation time. Therefore, the random effect model was used for the combined analysis of the effect amount. The results indicated that the time of neuroendoscopic surgery was much longer than that of MIPS (MD = 51.44; 95% CI 37.44-65.44, Z = 7.20, $P = 0.0001 < 0.05$), and the difference was statistically significant (Figure 6).

Comparison of hospitalization time of patients

A total of 6 articles[15,17,18,20-22] reported the comparison of hospitalization time of patients with sICH treated by the two methods. The heterogeneity analysis found that $I^2 = 94.85\%$, and there was high heterogeneity among the included literature. The difference in hospitalization time between different hospitals was relatively large. A random effect model was used to conduct a combined analysis of the effects. However, the results indicated no difference in hospitalization time between the two treatment methods for patients with sICH (MD = -1.63; 95% CI -3.96-0.71, Z = -1.36, $P = 0.17 > 0.05$), and the difference was not statistically significant (Figure 7).

Comparison of mRS scores of patients after operation

A total of 5 articles[17-20,22] reported the comparison of postoperative mRS scores of patients with sICH treated by the two methods. The heterogeneity analysis found that $I^2 = 62.03\%$, and the heterogeneity among the included literature was moderate. The combined analysis of effect sizes by random effect model found that the postoperative mRS scores of patients with sICH treated by

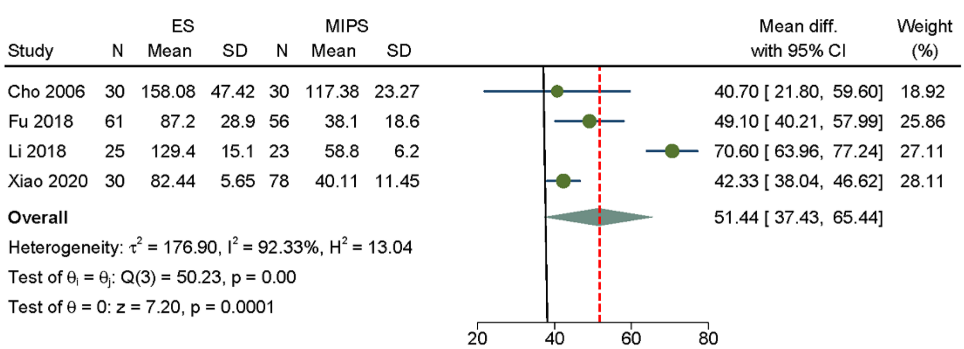

Figure 6. Comparison of postoperative complications of neuroendoscopic surgery and minimally invasive puncture surgery for spontaneous intracerebral hemorrhage

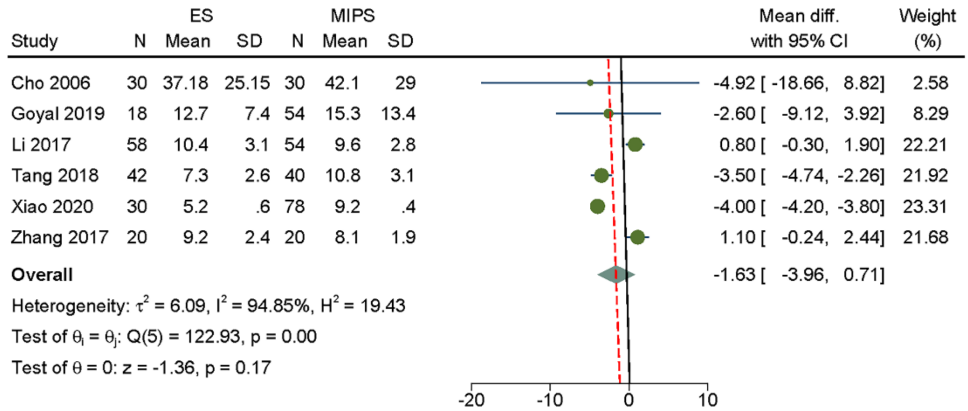

Figure 7. Comparison of hospitalization time between neuroendoscopic surgery and minimally invasive puncture surgery for spontaneous intracerebral hemorrhage

neuroendoscopic surgery were lower than those of MIPS (MD = -0.49; 95% CI -0.76 to -0.21, Z = -3.42, $P = 0.001 < 0.05$). The results showed that the postoperative recovery of patients with sICH treated by neuroendoscopic surgery was better than that of MIPS, and the difference was statistically significant (Figure 8).

Comparison of postoperative GCS scores of patients

A total of 5 articles[13-15,21-22] reported the comparison of postoperative GCS scores of patients with sICH treated by the two methods. The heterogeneity analysis found that $I^2 = 59.32\%$, indicating moderate heterogeneity among the included literature. The combined analysis of effect quantity by random effect model showed that the postoperative GCS score of patients with sICH treated by neuroendoscopic surgery was higher than that of MIPS (MD = 0.74; 95% CI 0.05-1.43, Z = 2.09, $P = 0.04 < 0.05$). The results showed that the postoperative consciousness recovery of patients with sICH treated by neuroendoscopic surgery was better than that of MIPS, and the difference was statistically significant (Figure 9).

Risk of bias assessment

The included outcome indicators, including hematoma clearance rate, hematoma clearance (mL), postoperative hematoma (mL), postoperative complications, operation time, hospital stay, mRS and GCS, were evaluated for risk bias using Egger's test. It was found that there was no risk bias between all outcome indicators (P>0.05).

DISCUSSION

sICH has a high mortality and disability rate, which seriously threatens people's life and health. The reason for the poor prognosis of cerebral hemorrhage is not only the initial injury and primary injury of brain tissue, such as inflammation, brain tissue edema, intracranial hypertension, and intracranial hemodynamic

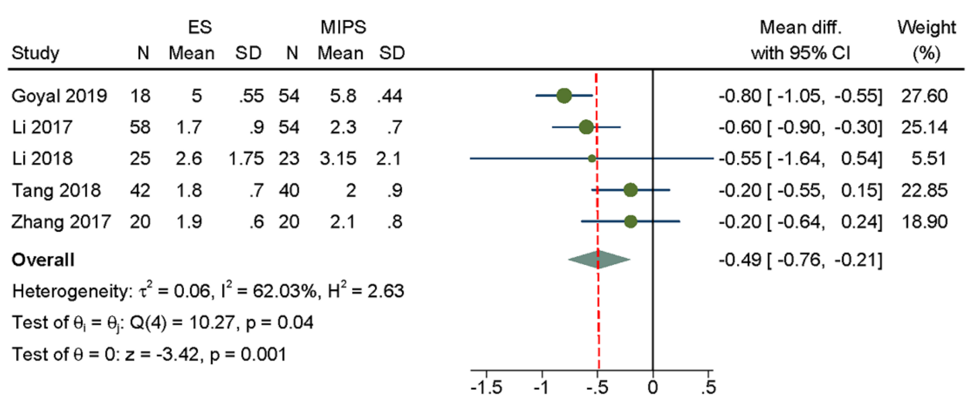

Figure 8. Comparison of postoperative mRS scores of patients with spontaneous cerebral hemorrhage treated by neuroendoscopic surgery and minimally invasive puncture surgery

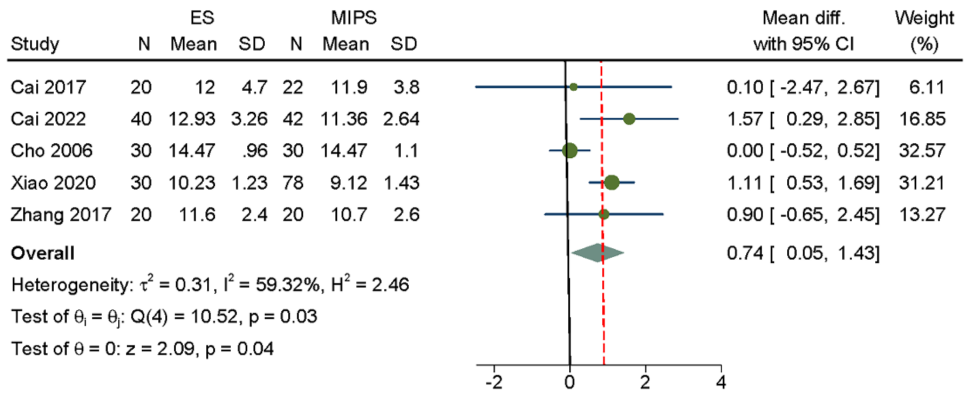

Figure 9. Comparison of postoperative GCS scores of patients with spontaneous intracerebral hemorrhage treated by neuroendoscopic surgery and minimally invasive puncture surgery

changes, but also secondary brain injury, such as secondary hematoma enlargement.[23,24] Meanwhile, water development around hematoma is also an important cause of early neurological deterioration.[25,26] Surgical treatment is for large blood clots caused by sICH. Relevant studies have shown that early surgery is beneficial to neurological function recovery and reduces complications.[14,22] Neuroendoscopic surgery and MIPS are both important methods for removing intracerebral hematoma, and both have their own advantages and disadvantages. With the introduction of minimally invasive techniques, the application of neuroendoscopic surgery in sICH is increasing. The operation domain of this method is clearer and can reduce blind operation. Hematoma clearance rate is higher, but the operation time is longer.[15,16,21] However, MIPS has less trauma and shorter operation time[15,16], but the hematoma clearance rate may be relatively low.[14,17,22] Therefore, we conducted a meta-analysis to compare the efficacy and safety of neuroendoscopic surgery and MIPS in the treatment of sICH.

A total of 10 literatures[13-22] were included in this study, including 763 patients with sICH, including 344 patients in the neuroendoscopy group and 419 patients in the MIPS group. The results of meta-analysis showed that compared with the MIPS group, the neuroendoscopy group had a higher hematoma clearance rate and a higher hematoma volume. Early hematoma removal can protect brain tissue from injury, so effective hematoma removal is an important principle to save life and improve long-term quality of life. The exact surgical method for cerebral hemorrhage has not been established. In the past few decades, craniotomy and hematoma removal have been the primary options, characterized by good vision, complete removal of hematoma, ease of hemostasis, and satisfactory reduction of intracranial pressure.[27,28] However, the trauma area of craniotomy is large and the postoperative recovery effect is not satisfactory.[4,29] Studies have reported that the clearance rate of hematoma in neuroendoscopic treatment is as high as 84% ~ 99%[13,30], much higher than MIPS. However, the non-operative time of this method is long ($P<0.05$), so it is not suitable for all cases. When some patients urgently need to reduce intracranial pressure, MIPS is more suitable.[31] Endoscopic neurosurgery is small in trauma area and easy to be illuminated by deep searchlight, which can effectively avoid brain tissue damage caused by blurred vision. The hematoma was completely removed, the therapeutic effect of the patient was improved, and the prognosis of the patient was also significantly improved. In this paper, we also reached a consensus that mRS Score was lower and GCS score was higher ($P<0.05$). The difference was statistically significant. Therefore, the efficacy and safety of endoscopic neurosurgery in the treatment of sICH are superior to MIPS.

This paper also has some limitations. Firstly, due to the characteristics of sICH, all the 10 articles included in this paper were retrospective cohort studies, which were inferior to randomized controlled studies of evidence-based medicine. Future research should aim to conduct large-scale, multicenter randomized controlled trials (RCTs) to enhance the generalizability of the findings. Additionally, standardizing the inclusion and exclusion criteria across studies will improve the comparability of results. Secondly, the study was limited to Chinese and English, which may also lead to some bias. Furthermore, the imaging methods used to evaluate hematoma clearance and postoperative recovery vary between studies, leading to potential inconsistencies in outcome assessments. Future studies should adopt standardized imaging protocols and advanced imaging technologies, such as high-resolution MRI or CT, to ensure more accurate and reproducible measurements. Emerging technologies and methodologies offer opportunities to overcome current limitations. For instance, the integration of artificial intelligence and machine learning algorithms in imaging and data analysis can enhance the precision of assessments and provide deeper insights into the factors influencing surgical outcomes. Most current studies focus on short-term outcomes, such as immediate postoperative recovery and hematoma clearance. Future research should include long-term follow-up to evaluate the sustained effects of neuroendoscopic surgery on functional outcomes, quality of life, and overall survival. This will provide a more comprehensive understanding of the long-term benefits and potential risks associated with the procedure. By addressing these limitations, future studies can better significantly advance our understanding and treatment of sICH.

This study integrates the literature on the influence of neuroendoscopic surgery and MIPS on sICH for meta-analysis. The results showed no statistical difference in postoperative complications, postoperative hematoma and hospital stay between neuroendoscopic surgery and MIPS. Still, the hematoma clearance and clearance rate of patients undergoing manual neuroendoscopic surgery were relatively high. The postoperative recovery (mRS) and consciousness recovery (GCS) were better after conducting neuroendoscopic surgery. The operation took longer in neuroendoscopy. Therefore, the effect of neuroendoscopic surgery in the treatment of sICH is better than that of MIPS.

DISCLOSURE

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Conflicts of Interest: None

REFERENCES

1. Yao Z, Hu X, You C, He M. Effect and feasibility of endoscopic surgery in spontaneous intracerebral hemorrhage: A systematic review and meta-analysis. *World Neurosurg* 2018; 113:348-56.e342. DOI: 10.1016/j.wneu.2018.02.022
2. Van Asch CJ, Luitse MJ, Rinkel GJ, Van Der Tweel I, Algra A, Klijn CJ. Incidence, case fatality, and functional outcome of intracerebral haemorrhage over time, according to age, sex, and ethnic origin: a systematic review and meta-analysis. *Lancet Neurol* 2010; 9(2): 167-76. DOI: 10.1016/S1474-4422(09)70340-0
3. Alberio N, Cicero S, Iacopino DG, *et al*. Minimally invasive management of spontaneous supratentorial intracerebral lobar hemorrhages by a “Homemade” endoscopic strategy: The evangelical doctrine of “Venite ad Me” allied to the legacy of King Leonida. *World Neurosurg* 2019; 122:638-47. DOI: 10.1016/j.wneu.2018.11.136
4. Yang K, Zhang Y, Song J, Zhang X, Wan W. Minimally invasive puncture and drainage versus craniotomy: basal ganglia intracerebral hemorrhage in elderly patients. *J Integr Neurosci* 2019; 18(2): 193-6. DOI: 10.31083/j.jin.2019.02.161
5. Wang Y, Duan K, Zhang A, Lv Y, Cao D. Clinical and imaging analysis of cerebral infarction caused by spontaneous cerebral artery dissection based on augmented reality technology. *J Healthc Eng* 2021; 2021:6671121. DOI: 10.1155/2021/6671121
6. Zhao J, Yuan F, Fu F, *et al.* Hypertension management in elderly with severe intracerebral hemorrhage. *Ann Clin Transl Neurol* 2021; 8(10): 2059-69. DOI: 10.1002/acn3.51455
7. Yang Z, Hong B, Jia Z, *et al*. Treatment of supratentorial spontaneous intracerebral hemorrhage using image-guided minimally invasive surgery: Initial experiences of a flat detector CT-based puncture planning and navigation system in the angiographic suite. *AJNR Am J Neuroradiol* 2014; 35(11): 2170-5. DOI: 10.3174/ajnr.A4009
8. Zhang Y, Shan AJ, Peng YP, *et al*. The intra-neuroendoscopic technique (INET): a modified minimally invasive technique for evacuation of brain parenchyma hematomas. *World J Emerg Surg* 2019; 14:21. DOI: 10.1186/s13017-019-0239-0
9. Zhou H, Zhang Y, Liu L, *et al*. Minimally invasive stereotactic puncture and thrombolysis therapy improves long-term outcome after acute intracerebral hemorrhage. *J Neurol* 2011; 258(4): 661-9. DOI: 10.1007/s00415-011-5902-7
10. Guo W, Liu H, Tan Z, *et al*. Comparison of endoscopic evacuation, stereotactic aspiration, and craniotomy for treatment of basal ganglia hemorrhage. *J Neurointerv Surg* 2020; 12(1): 55-61. DOI: 10.1136/neurintsurg-2019-014962
11. Goldstein JN, Gilson AJ. Critical care management of acute intracerebral hemorrhage. *Curr Treat Options Neurol* 2011; 13(2): 204-16. DOI: 10.1007/s11940-010-0109-2
12. Zhao J, Mao Q, Qian Z, Zhu J, Qu Z, Wang C. Effect of mild hypothermia on expression of inflammatory factors in surrounding tissue after minimally invasive hematoma evacuation in the treatment of hypertensive intracerebral hemorrhage. *Exp Ther Med* 2018; 15(6): 4906-10. DOI: 10.3892/etm.2018.6014
13. Cai Q, Zhang H, Zhao D, *et al*. Analysis of three surgical treatments for spontaneous supratentorial intracerebral hemorrhage. *Medicine* (Baltimore) 2017; 96(43): e8435. DOI: 10.1097/MD.0000000000008435

14. Cai Q, Wang W, Li Z, *et al*. New approach of minimally invasive evacuation for spontaneous supratentorial intracerebral hemorrhage. *Am J Transl Res* 2022; 14(3): 1969-78.
15. Cho DY, Chen CC, Chang CS, Lee WY, Tso M. Endoscopic surgery for spontaneous basal ganglia hemorrhage: comparing endoscopic surgery, stereotactic aspiration, and craniotomy in noncomatose patients. *Surg Neurol* 2006; 65(6): 547-55; discussion 555-6. DOI: 10.1016/j.surneu.2005.09.032
16. Fu C, Wang N, Chen B, *et al*. Surgical management of moderate basal ganglia intracerebral hemorrhage: Comparison of safety and efficacy of endoscopic surgery, minimally invasive puncture and drainage, and craniotomy. *World Neurosurg* 2019; 122:e995-e1001. DOI: 10.1016/j.wneu.2018.10.192
17. Goyal N, Tsivgoulis G, Malhotra K, *et al*. Minimally invasive endoscopic hematoma evacuation vs best medical management for spontaneous basal-ganglia intracerebral hemorrhage. *J Neurointerv Surg* 2019; 11(6): 579-83. DOI: 10.1136/neurintsurg-2018-014447
18. Li Z, Li Y, Xu F, Zhang X, Tian Q, Li L. Minimal invasive puncture and drainage versus endoscopic surgery for spontaneous intracerebral hemorrhage in basal ganglia. *Neuropsychiatr Dis Treat* 2017; 13:213-9. DOI: 10.2147/NDT.S120368
19. Li L, Li Z, Li Y, *et al*. Surgical evacuation of spontaneous cerebellar hemorrhage: Comparison of safety and efficacy of suboccipital craniotomy, stereotactic aspiration, and thrombolysis and endoscopic surgery. *World Neurosurg* 2018; 117:e90-e98. DOI: 10.1016/j.wneu.2018.05.170
20. Tang HT, JS-G, Chen G, Fu LQ. Clinical comparison of neuroendoscopy and puncture drainage for the treatment of spontaneous hypertensive intracerebral hemorrhage in basal ganglia. *China Prac Med* 2018; 13(25): 16-8. DOI:10.14163/j.cnki.11-5547/r.2018.25.008
21. Xiao T, Wan J, Qu H, Jiang W, Zhou X. Endoscopic surgery versus minimal puncture drainage surgery for treatment of supratentorial intracerebral hemorrhage. *Turk Neurosurg* 2020; 30(4): 565-72. DOI: 10.5137/1019-5149.JTN.27977-19.2
22. Zhang J, Lu J, Liao Q, Feng D, Li Y, Li S. Comparison of clinical efficacy of endoscopic surgery versus puncture drainage for patients with spontaneous intracerebral hemorrhage in basal ganglia. *J Shanxi Medical University* 2017; 48(3): 283-6. DOI: 10.13753/j.issn.1007-6611.2017.03.019
23. Steiner T, Bosel J. Options to restrict hematoma expansion after spontaneous intracerebral hemorrhage. *Stroke* 2010; 41(2): 402-9. DOI: 10.1161/STROKEAHA.109.552919
24. Okuda M, Suzuki R, Moriya M, Fujimoto M, Chang CW, Fujimoto T. The effect of hematoma removal for reducing the development of brain edema in cases of putaminal hemorrhage. *Acta Neurochir Suppl* 2006; 96:74-7. DOI: 10.1007/3-211-30714-1_18
25. Fujii Y, Tanaka R, Takeuchi S, Koike T, Minakawa T, Sasaki O. Hematoma enlargement in spontaneous intracerebral hemorrhage. *J Neurosurg* 1994; 80(1): 51-7. DOI: 10.3171/jns.1994.80.1.0051
26. Mayer SA. Hematoma enlargement in intracerebral hemorrhage. *J Neurosurg* 1994; 81(2): 333-4. DOI: 10.3171/jns.1994.81.2.0333a
27. Bösel J, Zweckberger K, Hacke W. Haemorrhage and hemicraniectomy: refining surgery for stroke. *Curr Opin Neurol* 2015; 28(1): 16-22. DOI: 10.1097/WCO.0000000000000167
28. Han WY, Tao YQ, Xu F, Zhang YQ, Li ZY, Liang GB. The short- and long-term efficacy analysis of stereotactic surgery combined external ventricular drainage in the treatment of the secondary intraventricular hemorrhage. *Brain Behav* 2017; 7(12): e00864. DOI: 10.1002/brb3.864
29. Mendelow AD, Gregson BA, Fernandes HM, *et al*. Early surgery versus initial conservative treatment in patients with spontaneous supratentorial intracerebral haematomas in the International Surgical Trial in Intracerebral Haemorrhage (STICH): a randomised trial. *Lancet* 2005; 365(9457): 387-97. DOI: 10.1016/S0140-6736(05)17826-X
30. Wang WH, Hung YC, Hsu SP, *et al*. Endoscopic hematoma evacuation in patients with spontaneous supratentorial intracerebral hemorrhage. *J Chin Med Assoc* 2015; 78(2): 101-7. DOI: 10.1016/j.jcma.2014.08.013
31. Marquardt G, Wolff R, Seifert V. Multiple target aspiration technique for subacute stereotactic aspiration of hematomas within the basal ganglia. *Surg Neurol* 2003; 60(1): 8-13; discussion 13-14. DOI: 10.1016/s0090-3019(03)00084-3