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Review Article

Application of ultrasound-based navigation in hypertensive intracerebral hemorrhage surgery: a meta-analysis

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Abstract: Objective: To explore the application of ultrasound-based navigation in surgery for hypertensive intracerebral hemorrhage (HICH). Methods: Databases such as CNKI, VIP, Wanfang, The Cochrane Library, Google Scholar, Embase, Medline, and PubMed were searched for meta-analyses. The effects of ultrasound-based navigation on surgery for hypertensive intracerebral haemorrhage were analyzed in terms of the amount of blood loss volume, hematoma evacuation rate, hospital stays, rebleeding, infection, deep vein thrombosis, surgical related complications and mortality. Results: Eighteen studies, containing 1491 HICH patients, were included in this meta-analysis (757 in experimental group and 734 in control group). The pooled results showed that compared to patients in the control group, patients in the experimental group undergoing ultrasound-assisted surgery had reduced blood loss ($P = 0.002$), hematoma evacuation rate ($P < 0.0001$), and hospital stays ($P < 0.00001$). In addition, ultrasound-based navigation in surgery had a positive effect on preventing postoperative rebleeding ($P = 0.002$), infection ($P = 0.005$), deep vein thrombosis ($P = 0.03$), and surgical related complications ($P < 0.00001$). However, in regarding mortality, no obvious difference was found ($P = 0.05$) between the two groups. Conclusion: Ultrasound-based navigation is effective in HICH surgery, which enables clinicians to optimize surgical treatment plans. However, due to the existence of some limitations, the conclusion needs to be validated by randomized controlled trials with high-quality and large sample size.

Keywords: Hypertensive intracerebral hemorrhage, surgery, ultrasound, application effect, meta-analysis

Introduction

Hypertensive intracerebral hemorrhage (HICH), also known as spontaneous intracranial hemorrhage (ICH), refers to the rupture of cerebral arterioles in patients when blood pressure rises rapidly, resulting in cerebral hemorrhage. HICH is very dangerous due to its rapid progression and high incidence. According to the data, the case fatality rate of patients in the first month of illness is as high as 40%, and 54% of patients will die within a year after the onset of HICH. Only 20% of patients are able to look after themselves within six months after treatment, so the pressure on the patient's family and society is tremendous [1, 2]. What is more serious is that the incidence of HICH is increasing year by year due to factors such as routines and eating habits [3]. Given the risks and hazards associated with HICH, it is crucial to provide effective treatments for HICH patients. Currently, the treatment of HICH relies primarily on non-surgical and surgical approaches [4]. Non-surgical treatment is highly safe and suitable for patients with a small amount of bleeding. For patients who are in critical condition with a large amount of bleeding, surgery is the first choice. The American Heart Association's guidelines for the treatment of cerebral hemorrhage suggest that patients with less than 10 ml of bleeding, aggravated neurological impairment, brainstem injury, and hydrocephalus induced by cerebral obstruction should be treated with surgery as soon as possible [5]. The most commonly used surgical procedures are craniotomy (CR), endoscopic surgery (ES) and microcatheter-directed thrombolysis. Currently, there is insufficient evidence to prove

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that these surgical treatment strategies are reasonable compared to non-surgical treatments, and no specific surgical treatments that can improve prognosis have been found. Recent years have seen the ongoing advancement of neurosurgical technology. Studies that used surgical aids to guide surgery have gained recent attention [6]. The aim was to reduce iatrogenic trauma and to achieve the best possible treatment result. Many research centers have reported that the application of real-time ultrasound-based navigation in surgery can greatly reduce the risk of surgery for patients and is good for prognosis [7, 8]. However, the application of ultrasound-based navigation in surgery is still a new field, and there is no consistent results of its effects. The aim of this study was to objectively assess the efficacy and safety of ultrasound-guided HICH surgery. To this end, a comprehensive search was conducted using various databases to investigate the effects of this treatment method on HICH patients. The study's findings are expected to improve the prognosis and reduce complications for those affected by HICH.

Materials and methods

This study follows the Preferred Reporting Items for Systems Reviews and Meta-Analyses (PRISMA) specification and has been registered on the PROSPERO, number CRD420251276335. (https://www.crd.york.ac.uk/prospero/).

Sources of materials

Studies on ultrasound-guided HICH surgery published in such databases as CNKI, VIP, Wanfang, The Cochrane Library, Google Scholar, Embase, Medline, and PubMed were searched with no limitation on the publication date using computer. Search strategy in Supplementary Materials.

Inclusion criteria

(1) Published clinical studies, including randomized controlled trials (RCTs) or OSs (prospective or retrospective observational study). (2) The study subjects were those who met the diagnostic criteria for HICH (2022 Guideline for the Management of Patients with Spontaneous Intracerebral Hemorrhage from the American Stroke Association) and were diagnosed using a head CT scan. (3) The experimental group was treated using ultrasound-based navigation during surgery, while this method was not used for the control group.

Exclusion criteria

(1) Patient's cerebral hemorrhage was caused by intracranial aneurysm, arteriovenous malformation, brain herniation, stroke, rather than hypertension. (2) The full text of the study was not available. (3) Case reports, reviews, letters, conference reports, guidelines, animal studies, etc. (4) Research title or abstract does not meet criteria. (5) Repeatedly published studies or studies with duplicate data.

Data extraction and quality evaluation

Two researchers extracted the data independently. NoteExpress software was used for managing the studies. Data were recorded and tabulated, including: (1) studies' basic characteristics: first author, year of publication, etc; (2) study subjects' basic information: average age, male-female ratio, disease diagnosis, and surgical options; (3) primary or secondary outcomes: primary outcomes included blood loss volume, hematoma evacuation rate, and hospital stays. Secondary outcomes included rebleeding, infection, deep vein thrombosis (DVT), surgical related complications and mortality. Surgical-related complications including rebleeding, infection (including wound infection, intracranial infection, pulmonary infection), gastrointestinal bleeding, cerebral infarction, hydrocephalus, DVT, wound bleeding, pulmonary embolism, and so on. The data were finally cross-checked by two researchers. Any disagreements were resolved by a third researcher. The methodologic quality of RCTs and OSs was assessed according to the Cochrane Collaboration's risk of bias tool [9] and the Newcastle-Ottawa Scale (NOS) [10] separately.

Statistical analysis

Data analysis was performed using RevMan 5.3. According to different data types, corresponding effect size was selected for statistical analysis. The effect size was combined using Mantel-Haenszel method. If there was low degree of heterogeneity ($I^2 \leq 50\%$, $P \geq 0.10$) or heterogeneity did not exist, a fixed-effect model was used for meta-analysis. Otherwise, a ran-

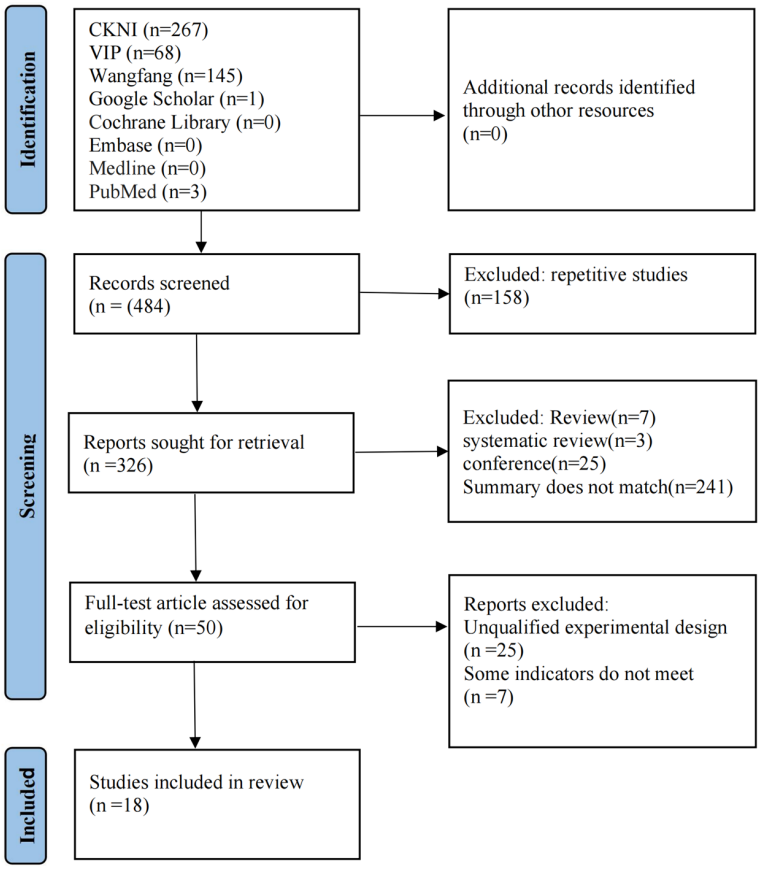

Figure 1. PRISMA flow diagram of the meta-analysis.

dom-effect model was used for meta-analysis. If necessary, sensitivity analysis was performed, and the results' stability was tested. The odds ratio (OR) with a 95% confidence interval (CI) was applied as the effect indicator for the dichotomous variables, and the weighted mean difference (MD) was used for the continuous variable. Each pooled result was expressed as a 95% confidence interval (95% CI). Publication bias was assessed by funnel plots. $P < 0.05$ was considered a significant difference.

Results

Study inclusion and quality assessment

Database screen revealed 484 records. 158 duplicates were excluded using NoteExpress software. Then 35 studies that were reviews, conference reports, and systematic reviews were excluded. After reading the abstract, 241 studies with ineligible content were excluded. After reviewing full text, 25 studies with unreasonable experimental design were excluded. In addition, 7 studies with incomplete data and ineligible outcome indicators were also excluded. Finally, 18 Chinese studies [11-28] were included (**Figure 1**). This meta-analysis included 1491 objects, including 757 in the experimental group and 734 in the control group.

The analysis comprised 12 RCTs and 6 OSs. The Cochrane ROB scores of the 12 included RCTs were all ≥ 4 points, of which 5 studies had 5 points, and 7 studies had 4 points. No RCTs had a low risk of bias, 5 had a medium risk of bias and 7 had a high risk of bias. The NOS scores of the 6 included OSs were all ≥ 7 points, of which 3 studies had a NOS score of 8 points, and 3 studies had 7 points, indicating that the included studies had high research quality (**Table 1**).

Results of meta-analysis

Blood loss volume: As shown in **Figure 2**, 10 studies [11-16, 19, 25, 26, 28] consisting of 806 patients, reported blood loss volumes in patients. Of these, 2 studies [13, 25] adopted ultrasound-assisted CR for the experimental group and only CR for the control group. Eight studies [11, 12, 14-16, 19, 26, 28] adopted ultrasound-assisted ES for the experimental group and only CR for the control group. Obvious heterogeneity was found in this comparison between the experimental group and the control group ($P < 0.00001$, $I^2 = 100\%$), so a random effect model was used. We found that the majority of results were to the left of the baseline. The two groups showed a significant difference in blood loss volumes (MD = -100.39; 95% CI: -163.50 to -37.28; $P = 0.002$), suggesting that ultrasound navigation effectively reduced intraoperative blood loss more than CR. Subgroup analysis showed that CR with ultrasound-based navigation resulted in a lower amount of bleeding than CR (MD = -118.83; 95% CI: -206.80 to -30.85; $P = 0.008$, with sub-

Table 1. Basic characteristics of included studies

Author & Year	Design	Disease diagnosis	Case, Gender (M/F), Age (y)		Method		Blood loss volume (mL)		Hospital stays (day)		Hematoma evacuation rate (%)		Surgical-related complications		Death		Quality evaluation
			E	C	E	C	E	C	E	C	E	C	E	C	E	C	
Duan X (2019) [11]	RCT	HICH	30, 17/13, 62.4±1.1	30, 16/14, 62.5±1.0	B-scan ultrasound +ES	CR	81.6±14.7	97.5±20.1	7.8±1.3	12.4±2.4	-	-	1	6	-	-	5
Guo Y (2018) [12]	RCT	HICH	75, 40/35, 55.1±7.3	75, 39/36, 55.3±6.8	B-scan ultrasound +ES	CR	49.7±10.3	321.9±40.5	-	-	-	-	1	4	-	-	4
He Z (2016) [13]	RCT	HICH	30, 18/12, 67.25±3.25	30, 17/13, 69.18±4.05	B-scan ultrasound +CR	CR	39.67±6.71	63.46±5.05	13.79±3.24	18.36±4.72	-	-	-	-	0	2	5
Huang C (2016) [14]	OS	HICH	28, 67.7±4.6	24, 66.4±4.3	B-scan ultrasound +ES	CR	124±14	200±16	10.7±1.2	15.1±1.5	-	-	-	-	-	-	7
Huang J (2020) [15]	RCT	HICH	30, 17/13, 48.63±11.39	30, 14/16, 48.49±11.67	B-scan ultrasound +ES	CR	137.64±9.16	402.18±12.39	15.18±3.74	19.43±4.25	-	-	-	-	-	-	5
Hu S (2017) [16]	RCT	HICH	75, 40/35, 55.1±7.3	75, 39/36, 55.3±6.8	B-scan ultrasound +ES	CR	49.7±10.3	321.9±10.5	-	-	-	-	1	4	-	-	4
Kuang H (2016) [17]	RCT	HICH	30, 15/15, 50±10	30, 14/16, 48±12	B-scan ultrasound +ES	CR	-	-	-	-	-	-	0	2	-	-	4
Li M (2018) [18]	RCT	HICH	50/50, 57/43, 47.62±8.33		Ultrasound +SBW	SBW	-	-	-	-	-	-	3	15	1	3	4
Liu Q (2020) [19]	RCT	HICH	30, 16/14, 60.7±10.3	30, 15/15, 61.3±10.5	B-scan ultrasound +ES	CR	80.2±13.5	105.6±30.2	-	-	-	-	1	4	-	-	4
Liu Z (2015) [20]	RCT	HBGH	16/16, 22/10, 42-67		B-scan ultrasound +ES	CR	-	-	-	-	95.1±6.1	90.2±5	2	5	-	-	4
Niu W (2018) [21]	RCT	HICH	44, 24/20, 50.2±11.0	44, 23/21, 48.1±9.8	Ultrasound +SBW	CR	-	-	-	-	-	-	0	2	-	-	4
Qin S (2018) [22]	OS	HICH	62, 38/24, 56.2±10.2	49, 32/17, 55.4±9.1	B-scan ultrasound +SBW	SBW	-	-	-	-	92.6±2.3	81.3±5.6	-	-	-	-	7
Wang G (2020) [23]	OS	HBGH	57, 43/14, 62.54±5.79	43, 31/12, 60.68±5.85	Ultrasound +SBW	SBW	-	-	-	-	-	-	3	6	2	5	8
Wang K (2015) [24]	OS	HICH	47, 27/20, 59.6±7.4	47, 29/18, 58.9±6.9	B-scan ultrasound +ES	CR	-	-	-	-	95.31±6.12	90.18±4.97	2	8	3	4	8
Yang F (2017) [25]	RCT	HICH	19, 11/8, 57.3±0.2	19, 10/9, 59.1±0.3	B-scan ultrasound +CR	CR	32.3±3	61.9±5.7	14.5±4.2	19.5±7.3	-	-	-	-	-	-	5
Ye Y (2017) [26]	OS	HICH	22, 16/6, 58.8±9.4	29, 18/11, 59.1±8.0	B-scan ultrasound +ES	CR	53.0±5.2	55.3±4.7	-	-	94.4±3.4	22.0±2.1	-	-	-	-	8
Zhu J (2021) [27]	OS	HICH	50/50, 56/44, 60.2±8.2		B-scan ultrasound +ES	CR	-	-	-	-	-	-	2	7	-	-	7
Zhu Y (2014) [28]	RCT	HICH	62/63, 68/57, 68±4		B-scan ultrasound +ES	CR	38±5	60±4	14±4	19±4	-	-	-	-	-	-	5

Abbreviations: RCT: randomized controlled trial; OS: observational study; HICH, hypertensive intracerebral hemorrhage; HBGH, hypertensive basal ganglia hemorrhage; ES, endoscopic surgery; CR, craniotomy; SBW, small bone window; E, experimental group; C, control group.

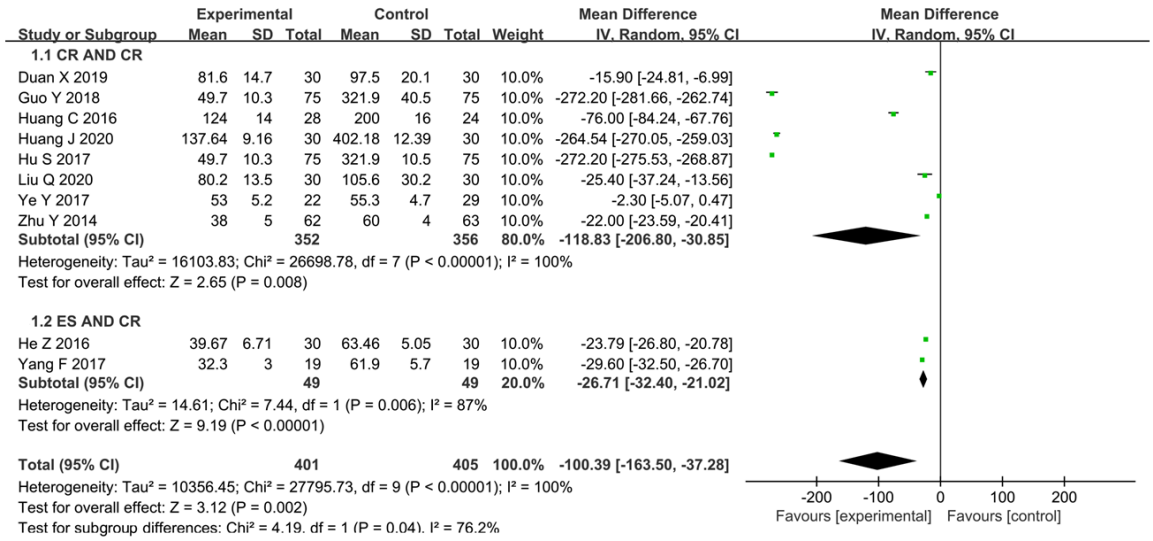

Figure 2. Mean difference estimate for blood loss volume between the experimental group and the control group.

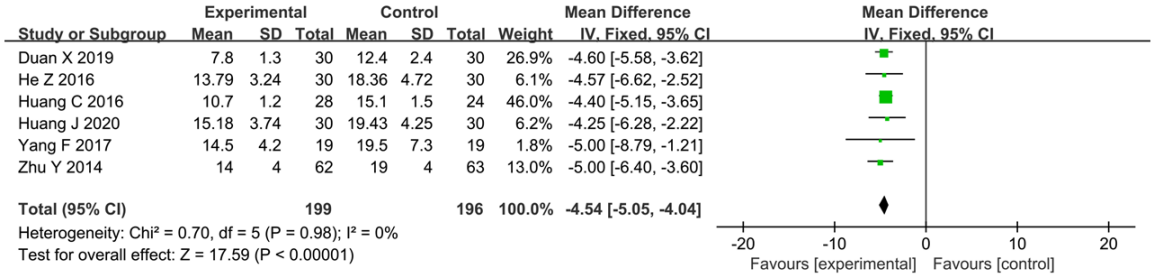

Figure 3. Mean difference estimate for hospital stays between the experimental group and control group.

stantial heterogeneity within this subgroup (P < 0.00001, I^2 = 100%). Similarly ES with ultrasound-based navigation resulted in lower amount of bleeding than CR (MD = -26.7; 95% CI: -32.40 to -21.02; P < 0.00001), and heterogeneity remained high within this subgroup (P < 0.006, I^2 = 87%). The high heterogeneity likely arose from multiple interrelated factors. First, differences in surgical techniques between CR and ES contributed to variability. Second, variations in ultrasound navigation practices, including equipment use and operational parameters, influenced the consistency of outcomes. Third, patient-level factors such as demographic characteristics and baseline health conditions affected bleeding risk and surgical complexity. Fourth, differences in sample sizes across studies, particularly between smaller and larger cohorts, introduced instability in effect estimates.

Hospital stays: A total of 6 studies [11, 13-15, 25, 28] reported hospital stays (n = 199 in the experimental group and 196 in the control group). Heterogeneity test showed low degree of heterogeneity between studies (P = 0.98, I^2 = 0%), so a fixed effect model was used for meta-analysis. The result suggested that Intraoperative assisted ultrasound navigation could shorten the hospital stays better than CR (MD = -4.54; 95% CI: -5.05 to -4.04; P < 0.00001; **Figure 3**).

Hematoma evacuation rate: Only 4 studies [20, 22, 24, 26] reported the hematoma evacuation rate. High heterogeneity was found between studies (P < 0.00001, I^2 = 89%). The random effect model was applied. The pooled results showed that the difference of hematoma evacuation rate was significant (MD = 7.09; 95% CI: 3.89 to 10.30, P < 0.0001), suggesting that Intraoperative assisted ultrasound navigation could Improve the hematoma clearance rate in surgery, as shown in **Figure 4A**. The outcome indicators for hematoma evacuation rate were found to be highly heterogeneous between

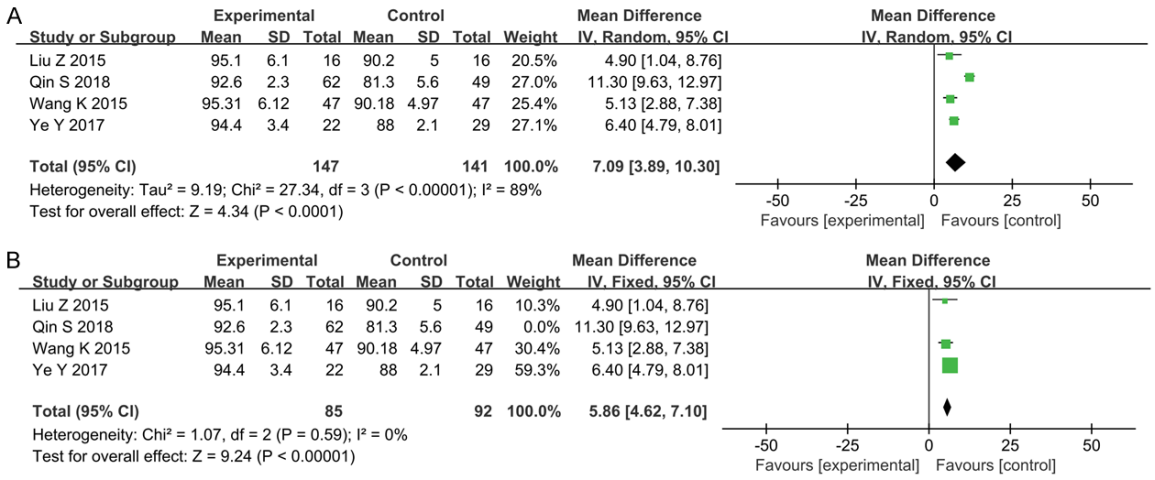

Figure 4. Mean difference estimation (A) and sensitivity analysis (B) of hematoma evacuation rate between the experimental group and the control group.

studies. The range of confidence intervals of the study by Qin et al. [22] and other scholars was wider than that of the other three studies. Therefore, the study's sensitivity was analysed. After excluding that study, the degree of heterogeneity was lower (P = 0.59, I^2 = 0%), as shown in **Figure 4B**.

Rebleeding, infection, DVT and surgical related complications: As shown in **Figure 5** (A: rebleeding; B: infection; C: deep vein thrombosis; D: surgical related complications), 5 studies [17, 18, 21, 24, 27] included data on rebleeding. At the same time, 8 studies [11, 12, 16, 19, 20, 23, 24, 27] mentioned data on infection and 7 studies [11, 17, 18, 20, 21, 24, 27] mentioned data on deep vein thrombosis. A total of 11 studies [11, 12, 16-21, 23, 24, 27] referenced surgical related complications data (see **Table 2**). As there was no significant heterogeneity between these studies, the fixed effects model was used. The postoperative rebleeding rate in the experimental group (n = 442; *OR* = 0.18; 95% CI: 0.06-0.53; P = 0.002), infection rate (n = 746; *OR* = 0.30; 95% CI: 0.13-0.70; P = 0.005), deep vein thrombosis rate (n = 534; *OR* = 0.34; 95% CI: 0.12-0.91; P = 0.03) and surgical related complication rate (n = 994; *OR* = 0.22; 95% CI: 0.13-0.38; P < 0.00001) were lower than the control group.

Mortality: Four studies [13, 18, 23, 24] reported the mortality. The degree of heterogeneity between studies was low (P = 0.79, I^2 = 0%), so a fixed effect model was used for meta-analysis. The results showed that intraoperative ultrasound navigation had no effect on mortality (*OR* = 0.39; 95% CI: 0.15-1.00; P = 0.05), as shown in **Figure 6**.

Publication bias: A publication bias analysis was carried out on studies that reported two indicators of blood loss volume and surgical related complications (**Figure 7**). The studies scattered on either side in a asymmetrical manner, suggesting that publication bias may be presented. All of the studies were written in Chinese, which caused a language bias.

Discussion

Cerebral hemorrhage often leads to death and disability due to its severity and rapid change [29]. In China, 18.8%-47.6% of hospitalized stroke patients experience cerebral hemorrhage [30]. The number of cerebral hemorrhage cases is as high as 50.6 to 80.7 per 100,000 people per year [31]. The incidence of cerebral hemorrhage is on the rise, and young people are becoming a larger proportion of patients [32]. Causes of cerebral haemorrhage include hypertension, atherosclerosis, arteriovenous malformations, intracranial aneurysms and blood diseases [33]. Eighty per cent of cerebral haemorrhages were caused by hypertension, and 50-70 per cent of bleeding sites were in the basal ganglia [34]. Between 20% and 30% of people die within three months of having a cerebral haemorrhage [35]. Those who survive are affected by varying degrees of disability

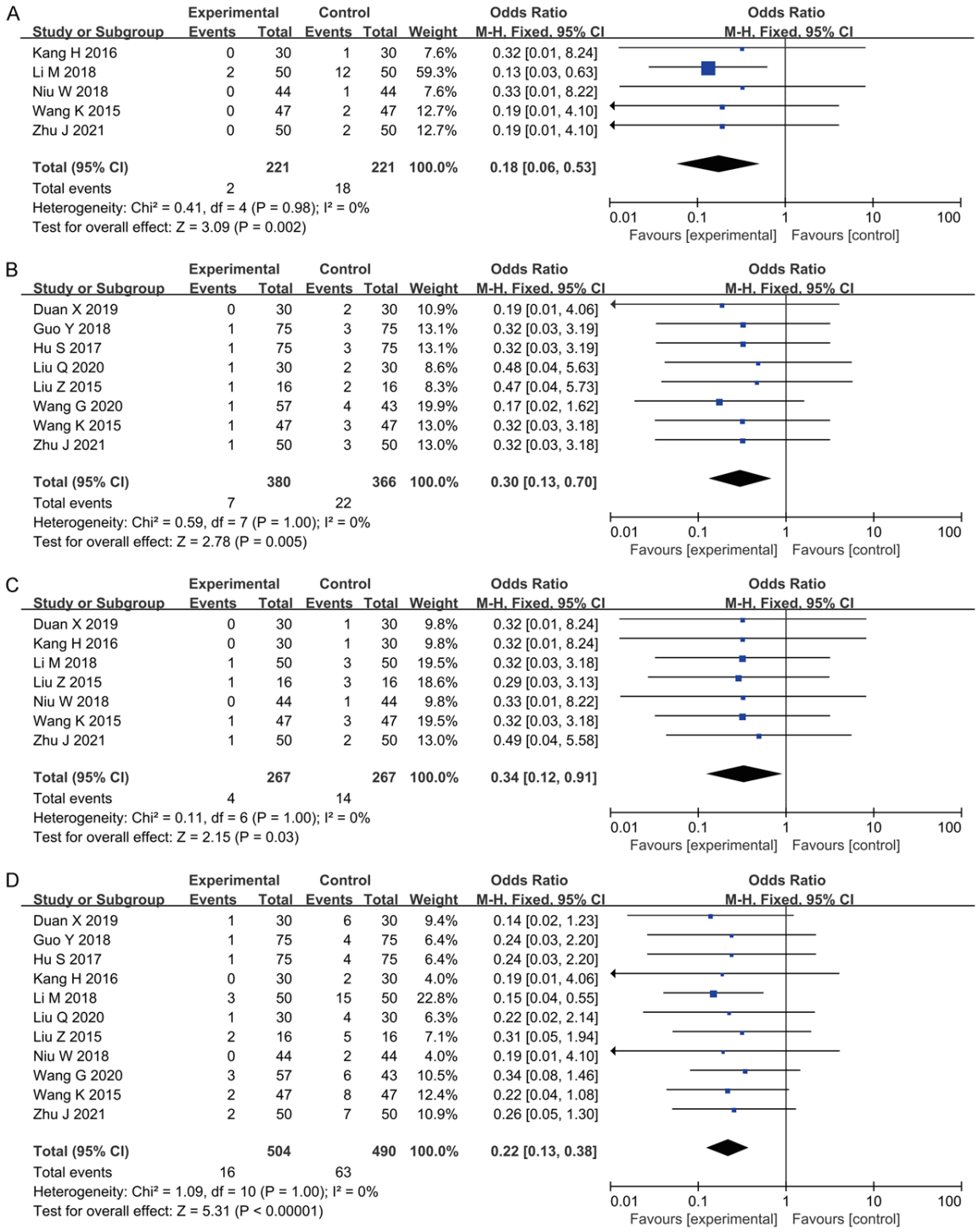

Figure 5. Odds ratio estimate for rebleeding (A), infection (B), deep vein thrombosis (C) and surgical-related complications (D) between the experimental group and control group.

[36]. Currently, the main treatment methods for HICH include drug therapy and surgery [4]. The advent of CT has greatly improved the surgical treatment of cerebral haemorrhage. However, it has been shown through practice that the value of the current surgical treatment of cerebral haemorrhage is still controversial [37]. The American Heart Association (AHA) pointed out that, for patients with spontaneous intracerebral haemorrhage and a haematoma within 1

Table 2. Surgical-related complications

Author & Year	Experimental group	Control group
Duan X (2019) [11]	1 case of bleeding at incision	1 case of bleeding at incision, 2 cases of intracranial infection, 2 cases of pulmonary embolism, and 1 case of deep vein thrombosis
Guo Y (2018) [12]	1 case of intracranial infection	3 cases of intracranial infection, 1 case of hydrocephalus
Hu S (2017) [16]	1 case of intracranial infection	3 cases of intracranial infection, 1 case of pulmonary embolism
Kang H (2016) [17]	None	1 case of re-bleeding, and 1 case of deep vein thrombosis
Li M (2018) [18]	2 case of rebleeding, and 1 case of deep vein thrombosis	12 case of rebleeding, and 3 cases of deep vein thrombosis
Liu Q (2020) [19]	1 case of intracranial infection	2 cases of intracranial infection, 2 cases of hydrocephalus
Liu Z (2015) [20]	1 case of intracranial infection, 1 case of deep vein thrombosis	2 cases of intracranial infection, 3 cases of deep vein thrombosis
Niu W (2018) [21]	None	1 case of deep vein thrombosis, 1 case of rebleeding
Wang G (2020) [23]	1 case of lung infection, 1 case of gastrointestinal bleeding, and 1 case of ischemic stroke	3 cases of lung infection, 1 case of intracranial infection, 1 case of gastrointestinal bleeding, and 1 case of ischemic stroke
Wang K (2015) [24]	1 case of intracranial infection, 1 case of deep vein thrombosis	3 cases of intracranial infection, 3 cases of deep vein thrombosis, 2 cases of rebleeding
Zhu J (2021) [27]	1 case of infection, 1 case of deep vein thrombosis	3 cases of infection, 2 cases of deep vein thrombosis, 2 cases of rebleeding

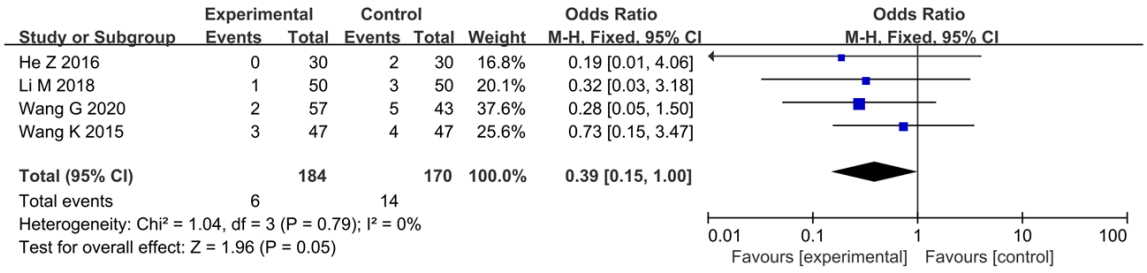

Figure 6. Odds ratio estimate for death between the experimental group and control group.

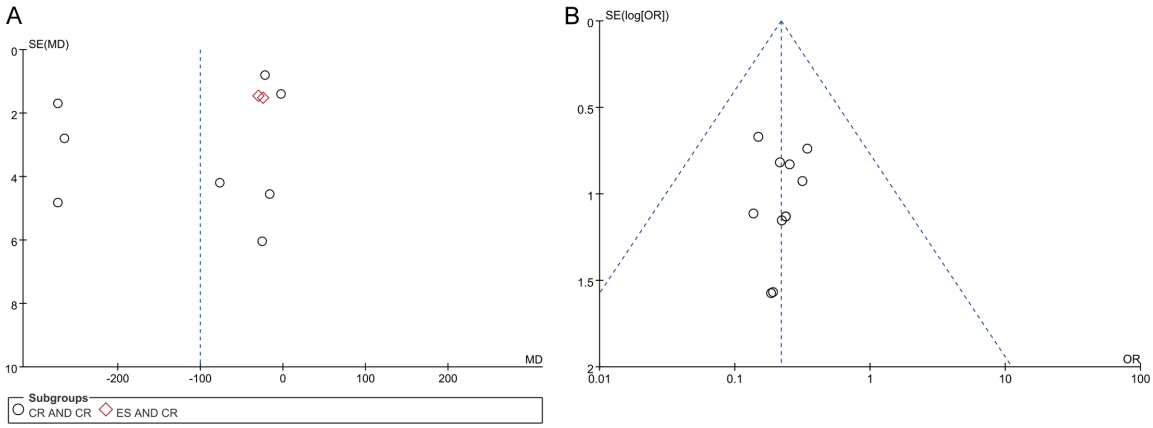

Figure 7. Funnel plot of blood loss volume (A) and surgical related complications (B). Abbreviations: ES, endoscopic surgery; CR, craniotomy; SBW, small bone window.

cm of the cerebral cortex, surgical treatment is superior to conservative treatment. However, surgery is not recommended for patients with a haemorrhage over 1 cm from the cerebral cortex [5]. In traditional surgery, bone flap craniotomy is mainly used, and the size of the bone window affects the effectiveness of the operation [38]. A bone window that is too large increases the risk of surgical infection, while one that is too small increases the difficulty of the procedure [39]. However, ultrasound-based navigation in cerebral haemorrhage surgery solves the problem of the surgical visual field to some extent [40]. With its help, surgery can be applied to more types of haematoma, offering greater advantages than traditional haematoma removal. As the concepts of precise positioning and minimally invasive procedures become more prevalent, endoscopic intracranial haematoma removal has gradually gained recognition and attention [41]. In particular, endoscopic surgery combined with B-mode ultrasound can accurately locate the haematoma and control the surgical path and procedure, thus avoiding tissue damage [42]. The results of the meta-analysis show that using ultrasound-based navigation in HICH surgery can reduce the blood loss volume. It can also reduce the time spent in hospital. Furthermore, it can increase the hematoma clearance rate. Finally, it can reduce postoperative complications. Miao et al. [43] conducted a randomized comparative study of B-ultrasound-guided microsurgery and craniotomy for the treatment of hypertensive basal ganglia haemorrhage. The study revealed that a significantly higher proportion of patients in the B ultrasound group (78.43%) achieved a haematoma clearance rate of over 90% during surgery than in the control group (60.71%). Furthermore, the B ultrasound group had a higher proportion of patients who made a good recovery six months after surgery than the control group. We therefore believe that surgical operations guided by B ultrasound can accurately locate the haematoma, select the nearest haematoma for puncture and reach its centre by endoscopy. This makes it possible to completely remove the haemorrhagic mass by suction and reduce the risk of re-bleeding.

Limitations

Although this study evaluated the application effects of ultrasound-guided surgery in hypertensive intracerebral hemorrhage through systematic retrieval and meta-analysis, several limitations remain. First, all included studies were published in Chinese, and some were observational studies. This may have introduced selection bias, confounding bias, and other biases, thereby affecting the reliability and generalizability of the results. In addition, there was some degree of heterogeneity among the included studies in terms of surgical approaches, baseline patient characteristics, ultrasound equipment, and procedural protocols. Although we attempted to control for these factors through subgroup analysis and sensitivity analysis, they may still have affected the stability of the pooled results. Therefore, the conclusions of this study need to be further validated by more high-quality, large-sample randomized controlled trials in the future.

Conclusion

Ultrasound-based navigation is effective in HICH surgery, which is significant for guiding clinicians to optimise surgical treatment plans. Due to the quality of the included studies, the conclusion needs to be validated by RCTs with high-quality and large sample size.

Disclosure of conflict of interest

None.

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Supplementary Materials

Search strategies

1) CNKI

#1 SU="Hypertensive cerebral hemorrhage" or "Spontaneous intracerebral hemorrhage" or "Cerebral hemorrhage in basal ganglia" or "HICH"

#2 SU="Ultrasound" or "Intraoperative ultrasound" or "B-scan ultrasound" or "doppler ultrasound" or "Real-time ultrasound"

#3 #1 AND #2

2) Wangfang

Theme:(("Hypertensive cerebral hemorrhage" or "Spontaneous intracerebral hemorrhage" or "Cerebral hemorrhage in basal ganglia") and ("Ultrasound" or "Intraoperative ultrasound" or "B-scan ultrasound" or "Doppler ultrasound" or "Real-time ultrasound") and ("Operation"))

3) VIP

M=((Hypertensive cerebral hemorrhage OR Spontaneous intracerebral hemorrhage OR Cerebral hemorrhage in basal ganglia) AND (Ultrasound OR Intraoperative ultrasound OR B-scan ultrasound OR Doppler ultrasound OR Real-time ultrasound))

4) PubMed

#1 (Intracranial Hemorrhage, Hypertensive[Title/Abstract])OR(Hemorrhage, Hypertensive Intracranial[Title/Abstract])OR(Hemorrhages, Hypertensive Intracranial[Title/Abstract])OR(Hypertensive Intracranial Hemorrhage[Title/Abstract])OR(Hypertensive Intracranial Hemorrhages[Title/Abstract])OR(Intracranial Hemorrhages, Hypertensive[Title/Abstract])OR(Hypertensive Hemorrhage, Intracranial[Title/Abstract])OR(Hemorrhage, Intracranial Hypertensive[Title/Abstract])OR(Hemorrhages, Intracranial Hypertensive[Title/Abstract])OR(Hypertensive Hemorrhages, Intracranial[Title/Abstract])OR(Intracranial Hypertensive Hemorrhage[Title/Abstract])OR(Intracranial Hypertensive Hemorrhages[Title/Abstract])OR(Cerebral Hemorrhage, Hypertensive[Title/Abstract])OR(Cerebral Hemorrhages, Hypertensive[Title/Abstract])OR(Hemorrhage, Hypertensive Cerebral[Title/Abstract])OR(Hemorrhages, Hypertensive Cerebral[Title/Abstract])OR(Hypertensive Cerebral Hemorrhage[Title/Abstract])OR(Hypertensive Cerebral Hemorrhages[Title/Abstract])OR(Intracerebral Hemorrhage, Hypertensive[Title/Abstract])OR(Hemorrhage, Hypertensive Intracerebral[Title/Abstract])OR(Hemorrhages, Hypertensive Intracerebral[Title/Abstract])OR(Hypertensive Intracerebral Hemorrhage[Title/Abstract])OR(Hypertensive Intracerebral Hemorrhages[Title/Abstract])OR(Intracerebral Hemorrhages, Hypertensive[Title/Abstract])OR(Hypertensive Hemorrhage, Cerebral[Title/Abstract])OR(Cerebral Hypertensive Hemorrhage[Title/Abstract])OR(Cerebral Hypertensive Hemorrhages[Title/Abstract])OR(Hemorrhage, Cerebral Hypertensive[Title/Abstract])OR(Hemorrhages, Cerebral Hypertensive[Title/Abstract])OR(Hypertensive Hemorrhages, Cerebral[Title/Abstract])

#2 (Diagnostic Ultrasound[Title/Abstract])OR(Diagnostic Ultrasounds[Title/Abstract])OR(Ultrasound, Diagnostic[Title/Abstract])OR(Ultrasounds, Diagnostic[Title/Abstract])OR(Ultrasound Imaging[Title/Abstract])OR(Imaging, Ultrasound[Title/Abstract])OR(Imagings, Ultrasound[Title/Abstract])OR(Echotomography[Title/Abstract])OR(Ultrasonic Imaging[Title/Abstract])OR(Imaging, Ultrasonic[Title/Abstract])OR(Sonography, Medical[Title/Abstract])OR(Medical Sonography[Title/Abstract])OR(Ultrasonographic Imaging[Title/Abstract])OR(Imaging, Ultrasonographic[Title/Abstract])OR(Imagings, Ultrasonographic[Title/Abstract])OR(Ultrasonographic Imagings[Title/Abstract])OR(Echography[Title/Abstract])OR(Diagnosis, Ultrasonic[Title/Abstract])OR(Diagnoses, Ultrasonic[Title/Abstract])OR(Ultrasonic Diagnoses[Title/Ab-

stract])OR(Ultrasonic Diagnosis[Title/Abstract])OR(Echotomography, Computer[Title/Abstract])OR(Computer Echotomography[Title/Abstract])OR(Tomography, Ultrasonic[Title/Abstract])OR(Ultrasonic Tomography[Title/Abstract])

#3 #1 AND #2