Factors Influencing Recanalization After Mechanical Thrombectomy With First-Pass Effect for Acute Ischemic Stroke: A Systematic Review and Meta-Analysis

Xuesong Bai1,2†, Xiao Zhang1,2†, Jie Wang1,2†, Yinhang Zhang1,2, Adam A. Dmytriw3, Tao Wang1,2, Ran Xu1,2, Yan Ma1,2, Long Li1,2, Yao Feng1,2, Carolina Severiche Mena4, Kun Yang1, Xue Wang6, Haiqing Song7, Qingfeng Ma7 and Liqun Jiao1,2,8*†

1 China International Neuroscience Institute, Beijing, China, 2 Department of Neurosurgery, Xuanwu Hospital, Capital Medical University, Beijing, China, 3 Neuroradiology & Neurointervention Service, Brigham and Women's Hospital, Harvard Medical School, Boston, MA, United States, 4 Pontifical Bolivarian University, Medellin, Colombia, 5 Department of Evidence-Based Medicine, Xuanwu Hospital, Capital Medical University, Beijing, China, 6 Medical Library, Xuanwu Hospital, Capital Medical University, Beijing, China, 7 Department of Neurology, Xuanwu Hospital, Capital Medical University, Beijing, China, 8 Department of Interventional Neuroradiology, Xuanwu Hospital, Capital Medical University, Beijing, China

Background: First-pass effect (FPE) is increasingly recognized as a predictor of good outcome in large vessel occlusion (LVO). This systematic review and meta-analysis aimed to elucidate the factors influencing recanalization after mechanical thrombectomy (MT) with FPE in treating acute ischemic stroke (AIS).

Methods: Main databases were searched for relevant randomized controlled trials (RCTs) and observational studies reporting influencing factors of MT with FPE in AIS. Recanalization was assessed by the modified thrombolysis in cerebral ischemia (mTICI) score. Both successful (mTICI 2b-3) and complete recanalization (mTICI 2c-3) were observed. Risk of bias was assessed through different scales according to study design. The I² statistic was used to evaluate the heterogeneity, while subgroup analysis, meta-regression, and sensitivity analysis were performed to investigate the source of heterogeneity. Visual measurement of funnel plots was used to evaluate publication bias.

Results: A total of 17 studies and 6,186 patients were included. Among them, 2,068 patients achieved recanalization with FPE. The results of meta-analyses showed that age [mean deviation (MD): 1.21, 95% confidence interval (CI): 0.26–2.16; p = 0.012], female gender [odds ratio (OR): 1.12, 95% CI: 1.00–1.26; p = 0.046], diabetes mellitus (DM) (OR: 1.17, 95% CI: 1.01–1.35; p = 0.032), occlusion of internal carotid artery (ICA) (OR: 0.71, 95% CI: 0.52–0.97; p = 0.033), occlusion of M2 segment of middle cerebral artery (OR: 1.36, 95% CI: 1.05–1.77; p = 0.019), duration of intervention (MD: −27.85, 95% CI: −42.11–13.58; p < 0.001), time of onset to recanalization (MD: −34.63, 95% CI: −58.45–10.81; p = 0.004), general anesthesia (OR: 0.63, 95% CI: 0.52–0.77; p < 0.001), and use of balloon guide catheter (BGC) (OR: 1.60, 95% CI: 1.17–2.18; p = 0.003) were significantly associated with successful recanalization with FPE. At the same time, age, female gender, duration of intervention, general anesthesia, use of BGC, and occlusion...
Science, and the Cochrane Library. Clinical trial registers were
from the following databases: MEDLINE, EMBASE, Web of
Science, and the Cochrane Library. Clinical trial registers were
also searched as potential sources. The included studies
were restricted to the publication time before October
31, 2020, and the English language. The following key
words were used: “acute ischemic stroke,” “mechanical
thrombectomy,” “endovascular thrombectomy,” “first pass
effect,” “first attempt,” “recanalization.” A search strategy Table is
presented in detail in the online supplementary material (online
Supplementary Table 1).

INTRODUCTION

Stroke is the second-leading cause of global morbidity and
mortality (1, 2). Mechanical thrombectomy (MT) has been
widely used to treat acute ischemic stroke (AIS) patients and
has proved superior over intravenous tissue-type plasminogen
activator (tPA) by several landmark randomized trials (RCTs)
(3–6). Thus, the American Heart and American Stroke
Association recommends MT as the first-line therapy for
selected AIS patients with proximal artery large vessel occlusions
(LVO) (2).

However, some trials showed that functional independence in
AIS patients is only around 50% even with a high recanalization
rate of over 70% (3, 6). Thrombectomy with first pass effect
(FPE), an emerging new metric, is strongly correlated with
improved functional outcomes (7–10). Thrombectomy with FPE
may have many advantages such as less vessel wall injury, lower
risk of clot fragments, and decreased time to reperfusion (8, 11).
Also, FPE is associated with better outcomes than MPE
after achieving successful or complete recanalization (12). Thus,
identifying factors influencing FPE could help clinicians and
interventionalists maximize the benefit of MT through suitable
patient selection and pre-interventional risk modification. There
are many studies seeking to explore this phenomenon, but with
inconsistent results (7, 8, 11, 13–20). For example, balloon guide
catheters (BGC) and non-internal carotid artery (ICA) terminus
occlusion were correlated with FPE in the study of Zaidat et al.
(7), but factors such as older age, a lower systolic blood pressure,
and conscious sedation were not (17).

Thus, this systematic review and meta-analysis seeks to
summarize the current literature investigating influencing factors
of thrombectomy with first pass and elucidate associations
with it.

METHODS

This study was reported in conformity to the criterion of
Preferred Reporting Items for Systematic Reviews and Meta-
Analyses (PRISMA) (21).

Search Strategy

Eligible studies were independently searched by two reviewers
from the following databases: MEDLINE, EMBASE, Web of
Science, and the Cochrane Library. Clinical trial registers were
also searched as potential sources. The included studies
of ICA were associated with complete reperfusion with FPE, but M2 occlusion and DM
were not.

Conclusion: Age, gender, occlusion site, anesthesia type, and use of BGC were
influencing factors for both successful and complete recanalization after first-pass
thrombectomy. Further studies with more comprehensive observations indexes are need
in the future.

Keywords: acute ischemic stroke, mechanical thrombectomy, first pass effect, influencing factors, systematic
review, meta-analysis

Study Selection

Patient Selection Criteria

Inclusion criteria included age ≥18 years with AIS due to large
vessel occlusion, including the anterior or posterior circulation.
Arterial occlusion was confirmed by computed tomographic
angiography (CTA), magnetic resonance angiography (MRA),
or digital subtraction angiography (DSA). Exclusion criteria
included patients with baseline pre-stroke mRS score ≥3
and artery occlusion of non-atherosclerotic etiology such as
dissection, moyamoya disease, vasospasm, or vasculitis.
Patients with ICH, significant cerebellar mass effect, and acute
hydrocephalus on CT or MRI before the onset of stroke were
also excluded.

Definitions

FPE was defined as achieving successful or complete
recanalization by MT after first pass regardless of thrombectomy
device, such as contact aspiration and stent retriever. By
contrast, non-FPE was defined as failure to achieve successful
or complete recanalization by MT after first pass using
different thrombectomy devices, such as contact aspiration and
stent retriever.

Outcome

The primary outcome was successful recanalization with FPE,
and secondary outcome was complete recanalization with
FPE. The definitions of successful recanalization and complete
recanalization were up to modified thrombolysis in cerebral
ischemia (mTICI) score of 2b-3 and 2c-3 respectively after MT
by post-interventional DSA as per usual convention (22, 23).

Studies

RCTs and observational studies including cohort studies, case-
controlled studies, and case series where the number of patients
exceeded 10 were included to avoid type II errors from low power
(24, 25). Case reports, conference abstracts, or case series reports
with the number of included patients <10 were excluded.
Selection of Studies and Data Extraction

Studies which qualified were extracted by two independent reviewers (YZ and RX). In the initial stage of screening, titles, keywords, and abstracts were screened, and irrelevant studies were then excluded. Subsequently, reviewers obtained the full articles of all the remaining studies and checked the full texts to ascertain the included variables. In addition, the reasons for inclusion or exclusion of studies after full-text check were recorded. Disagreement in study selection between two reviewers was resolved by a third reviewer (TW).

Two reviewers independently (LL and XW) extracted the data according to a standardized data extraction form. The extracted information of included studies was as follows: (1) Authors, publication time, country, number of patients in FPE and non-FPE groups, inclusion and exclusion criteria; (2) Mean age, gender, medical history, site of occlusion by angiography, admission NIHSS score, baseline ASPECTS, MT strategy, use of tPA, and procedural times. The resolution of disagreement regarding data extraction was achieved through assistance of a third reviewer (TW). For missing or unclear data in included

![Flow diagram for systematic review and meta-analysis.](image)

**TABLE 1** | Main characteristics of included studies.

| Reference                  | Publication time | Included patients (n) | FPE (n, %) | Recruit period       | Recanalization | Location | Center  |
|----------------------------|------------------|-----------------------|-----------|----------------------|----------------|----------|---------|
| Velasco Gonzalez et al.    | 2020             | 200                   | 102, 51.0 | 2016.1–2018.12       | Complete       | Europe   | Single  |
| Srivatsa et al. (19)       | 2020             | 76                    | 35, 46.1  | 2016-2018            | Complete       | North America | Single |
| Mokin M et al. (18)        | 2020             | 609                   | 140, 23.0 | 2013.3–2015.8        | Complete       | North America | Multiple |
| Mohammaden et al. (11)     | 2020             | 436                   | 254, 58.3 | 2012.1–2019.5        | Complete       | North America | Single |
| Kang DH et al. (9)         | 2020             | 344                   | 66, 19.2  | 2011.1–2015.12       | Complete       | Asia     | Multiple |
| Ducroux et al. (28)        | 2020             | 336                   | 97, 28.9  | 2015.10–2016.10      | Complete       | Europe   | Multiple |
| Di Maria et al. (17)       | 2020             | 1832                  | 417, 22.8 | 2013.10–2018.4       | Complete       | Europe   | Multiple |
| Garcia-Tornel et al. (10)  | 2020             | 459                   | 213, 46.4 | 2012-2019            | Successful     | Europe   | Single  |
| Yi et al. (16)             | 2019             | 61                    | 25, 41.0  | 2015.1-2016.10       | Successful     | Asia     | Single  |
| Tomasello et al. (15)      | 2019             | 193                   | 97, 50.3  | 2017.2–2017.6        | Successful     | Europe   | Multiple |
| Nikoubashman et al. (29)   | 2019             | 164                   | 62, 37.8  | 2010.5–2018.1        | Complete       | Europe   | Single  |
| Anadani et al. (8)         | 2019             | 524                   | 178, 34.0 | 2013.11–2018.1       | Complete       | North America | Multiple |
| Zaidat et al. (7)          | 2018             | 345                   | 89, 25.8  | 2012.3–2013.2        | Complete       | North America | Multiple |
| Imahori et al. (30)        | 2018             | 50                    | 21, 42.0  | 2015.7–2017.6        | Successful     | Asia     | Single  |
| Flottmann et al. (31)      | 2018             | 330                   | 151, 46   | 2019-2017            | Successful     | Europe   | Single  |
| Baek et al. (13)           | 2017             | 136                   | 68, 50.0  | 2010.9–2015.8        | Successful     | Asia     | Single  |

FPE, first-pass effect.
studies, effort was made to contact the corresponding authors by e-mail in order to best guarantee the accuracy of data.

**Assessment Risk Bias and Heterogeneity**

Two reviewers (YF and CSM) independently assessed the risk of bias of each included study. The Cochrane Collaboration criteria were applied for RCTs, and the Newcastle–Ottawa scale was used for observational studies, including cohort studies and case–control studies (26). For case series, the method described in Methodological Quality and Synthesis of Case Series and Case Reports was applied (27). The heterogeneity of pooled outcomes was evaluated by the $I^2$ statistic. The $I^2$ statistic that was >60% demonstrated high heterogeneity, and the DerSimonian and Laird method for random-effect estimation was performed for pooling outcomes. If heterogeneity was mild or moderate, the Mantel–Haenszel method for fixed-effect estimation was applied. In instances where heterogeneity of outcomes and sufficient studies were high, we conducted subgroup analysis by site of occlusion, such as anterior circulation or posterior circulation. The meta-regression and sensitivity

| Table 2 | Summary of meta-analysis of influencing factors for achieving successful recanalization with FPE. |
|---------|------------------------------------------------------------------------------------------------------------------|
|         | WMD/OR  | 95%CI   | $I^2$ (%) | P-value |
| Age     | 1.21    | 0.26    | 2.16      | 20.1     | 0.012   |
| Gender, female | 1.12    | 1.00    | 1.26      | 22.2     | 0.046   |
| Hypertension | 1.10    | 0.97    | 1.26      | 43.1     | 0.134   |
| Diabetes mellitus | 1.17    | 1.01    | 1.35      | 0.0      | 0.032   |
| CAD     | 0.88    | 0.69    | 1.13      | 0.0      | 0.320   |
| Smoke   | 0.93    | 0.80    | 1.09      | 7.4      | 0.364   |
| Atrial fibrillation | 0.96    | 0.67    | 1.38      | 77.2     | 0.836   |
| Previous anticoagulation therapy | 1.16    | 0.93    | 1.45      | 20.6     | 0.197   |
| Dyslipidemia | 1.08    | 0.95    | 1.23      | 0.0      | 0.227   |
| Initial NIHSS score | −0.65   | −1.34   | 0.05      | 0.0      | 0.067   |
| Systolic blood pressure | −1.31   | −3.41   | 0.80      | 17.0     | 0.223   |
| Diastolic blood pressure | −0.66   | −2.12   | 0.79      | 42.0     | 0.374   |
| Suspected stroke etiology | Large artery atherosclerosis | 1.07    | 0.76    | 1.51      | 0.0      | 0.710   |
| Cardioembolic | 1.01    | 0.60    | 1.70      | 72.3     | 0.973   |
| Other   | 1.13    | 0.92    | 1.38      | 51.8     | 0.240   |
| IV thrombolysis | 1.015   | 0.904   | 1.141     | 0.0      | 0.798   |
| Stroke demographics | Laterality | Right    | 0.56    | 0.14    | 2.15      | 93.4     | 0.398   |
|         |         | Left     | 1.24    | 0.21    | 7.27      | 90.2     | 0.812   |
| Location of occlusion | ICA    | 0.71    | 0.52    | 0.97      | 70.6     | 0.033   |
|         | M1      | 1.25    | 0.88    | 1.77      | 81.5     | 0.206   |
|         | M2      | 1.36    | 1.05    | 1.77      | 37.5     | 0.019   |
|         | Tandem occlusion | 0.86    | 0.34    | 2.13      | 0.0      | 0.737   |
|         | Ipsilateral AComA and PComA | 0.73    | 0.42    | 1.24      | 34.7     | 0.243   |
| Intervention characteristics | Time of onset to puncture | 20.42   | 0.00    | 40.83     | 0.0      | 0.050   |
|         | Duration of intervention | −27.85  | −42.11  | −13.58    | 94.1     | <0.001  |
|         | Time of onset to recanalization | −34.63  | −58.45  | −10.81    | 0.0      | 0.004   |
|         | General anesthesia | 0.63    | 0.52    | 0.77      | 4.7      | <0.001  |
|         | Aspiration only | 1.31    | 0.62    | 2.76      | 81.9     | 0.481   |
|         | Stent retriever only | 1.07    | 0.58    | 1.96      | 78.3     | 0.839   |
|         | Aspiration and stent retriever both | 0.59    | 0.20    | 1.72      | 90.3     | 0.334   |
|         | Use of BGC | 1.60    | 1.17    | 2.18      | 71.6     | 0.003   |
|         | Migration to new territory | 0.55    | 0.25    | 1.22      | 0.0      | 0.142   |

FPE, first-pass effect; WMD, weighted mean difference; OR, odds ratio; CI, confidence interval; $I^2$, the variation attributable to heterogeneity; CAD, coronary artery disease; NIHSS, National Institutes of Health Stroke Scale; IV, intravenous; ICA, internal carotid artery; M1, M1 segment of middle cerebral artery; M2, M2 segment of middle cerebral artery; AComA, anterior communicating artery; PComA, posterior communicating artery; BGC, balloon-guided catheter. Bold values mean P-value with significant difference.
Statistical Analysis

The STATA statistical software package (version 15.0, StataCorp, College station, Texas, USA) was used for all data analysis and heterogeneity assessments. For dichotomous data, we adopted odds ratios (OR) with 95% confidential interval (CI), and the mean difference (MD) with 95% CI was used for continuous data. The standard of $p$-value <0.05 was regarded as statistically significant. If the number of included studies was more than 10, publication bias was assessed by visualization of a funnel plot.

RESULTS

Study Selection and Study Characteristics

There were 924 records identified through the main database and clinical trials registers, and 16 studies were finally eligible for inclusion in the qualitative and quantitative analysis. The flow diagram of study selection is demonstrated in Figure 1.

Table 1 depicts the characteristics of included studies. A total of 16 studies and 6,095 patients were eligible according to inclusion criteria. Among them, 2015 (33.1%) patients achieved recanalization with FPE. All studies were published after 2016, seven conducted in Europe, five conducted in North America, and four in Asia. There were seven multicenter studies, and the remaining were single-center investigations. The number of patients in each study ranged from 50 to 1,832, and the numbers of male and female patients were essentially equal [2,929 (50.05%) vs. 2,923 (49.95%)]. Mean NIHSS scores ranged from 2 to 28. The location of occlusion by angiography was mostly within the anterior circulation, such as ICA and middle cerebral artery (MCA), particularly the M1 and M2 segments (Online Supplementary Table 2).

Influencing Factors

The following factors were assessed: age, gender, hypertension, DM, coronary artery disease, smoking history, atrial fibrillation, dyslipidemia, previous anticoagulation therapy, initial NIHSS score, systolic blood pressure, diastolic blood pressure, suspected stroke etiology, IV thrombolysis, stroke laterality, location

![Figure 2](https://www.frontiersin.org)
of occlusion, anterior communicating artery (ACoA) and posterior communicating artery (PCoA) presence, and intervention characteristics.

**Determinants for Achieving Successful Recanalization With FPE**

The outcomes of meta-analysis showed that age (MD: 1.21, 95% CI: 0.26–2.16; $p = 0.012$), female gender (OR: 1.12, 95% CI: 1.00–1.26; $p = 0.046$), DM (OR: 1.17, 95% CI: 1.01–1.35; $p = 0.032$), ICA location (OR: 0.71, 95% CI: 0.52–0.97; $p = 0.033$), M2 segment (OR: 1.36, 95% CI: 1.05–1.77; $p = 0.019$), duration of intervention (MD: $-27.85$, 95% CI: $-42.11$–$-13.58$; $p < 0.001$), time of onset to recanalization (MD: $-34.63$, 95% CI: $-58.45$–$-10.81$; $p = 0.004$), general anesthesia (OR: 0.63, 95% CI: 0.52–0.77; $p < 0.001$), and use of BGC (OR: 1.81, 95% CI: 1.27–2.59; $p = 0.001$) were significantly associated with successful recanalization with FPE (Figures 2, 3). The remainder were not significantly correlated with achieving successful recanalization with FPE (online Supplementary Figures 1, 2).

**Determinants for Achieving Complete Recanalization With FPE**

Table 3 summarizes the results of meta-analysis of factors influencing complete recanalization with FPE. Age (MD: 1.43, 95% CI: 0.39–2.48; $p = 0.007$), female gender (OR: 1.20, 95% CI: 1.06–1.37; $p = 0.006$), ICA (OR: 0.66, 95% CI: 0.45–0.97; $p = 0.035$), duration of intervention (MD: $-27.85$, 95% CI: $-42.11$–$-13.58$; $p < 0.001$), general anesthesia (OR: 0.65, 95% CI: 0.54–0.80; $p < 0.001$), and use of BGC (OR: 1.81, 95% CI: 1.27–2.59; $p = 0.001$) were significantly associated with the complete recanalization with FPE (Figures 4, 5). The remainder were not significantly correlated with achieving successful recanalization with FPE (Online Supplementary Figures 3, 4).

**Risk of Bias in Studies Included**

The Newcastle–Ottawa scale was used to assess the bias risk of observational studies, such as case–control studies, with the majority of included studies being low risk bias (online Supplementary Table 3). Both meta-regression and sensitive analysis were conducted to explore the potential heterogeneity. We also used funnel plots to explore the publication bias, with the results demonstrating no evident reporting bias (Supplementary Figures 5–16).

**DISCUSSION**

In this systematic review and meta-analysis, the proportion of FPE ranged from 19 to 58% in the endovascular treatment of LVO inclusive of M2 occlusions. Factors contributing to successful recanalization with FPE included age, female gender, DM, general anesthesia, use of BGC, and occlusion of ICA and M2 segment. Among those, age, female gender, general anesthesia, use of BGC, and occlusion of ICA also increased the chance of complete reperfusion after first-pass thrombectomy.
**TABLE 3** | Summary of meta-analysis of influencing factors for achieving complete recanalization with FPE.

|                     | WMD/OR | 95% CI      | \(I^2\) (%) | P-value |
|---------------------|--------|-------------|-------------|---------|
| Age                 | 1.43   | 0.39        | 2.48        | 28.2%   | 0.007   |
| Gender, female      | 1.20   | 1.06        | 1.37        | 0.0%    | 0.006   |
| Hypertension        | 1.06   | 0.92        | 1.22        | 37.1%   | 0.423   |
| Diabetes mellitus   | 1.14   | 0.97        | 1.34        | 0.0%    | 0.106   |
| CAD                 | 0.81   | 0.61        | 1.07        | 0.0%    | 0.131   |
| Smoke               | 0.96   | 0.80        | 1.14        | 0.0%    | 0.605   |
| Atrial fibrillation | 0.97   | 0.81        | 1.17        | 61.8%   | 0.747   |
| Previous anticoagulation therapy | 1.16   | 0.93        | 1.45        | 20.6%   | 0.197   |
| Dyslipidemia        | 1.08   | 0.94        | 1.24        | 0.0%    | 0.286   |
| Initial NIHSS score | −0.54  | −1.26       | 0.17        | 0.0%    | 0.135   |
| Systolic blood pressure | −1.91  | −4.25       | 0.43        | 11.2%   | 0.109   |
| Diastolic blood pressure | −1.53  | −3.26       | 0.19        | 0.0%    | 0.081   |

**Suspected stroke etiology**

- Large artery atherosclerosis: 1.09 (0.77, 1.56) \(I^2\) = 60.0%, P = 0.617
- Cardioembolic: 1.01 (0.60, 1.70) \(I^2\) = 72.3%, P = 0.973
- Other: 1.12 (0.92, 1.38) \(I^2\) = 67.6%, P = 0.261
- IV thrombolysis: 0.99 (0.87, 1.13) \(I^2\) = 0.0%, P = 0.940

**Stroke demographics**

- Laterality: Right 0.81 (0.14, 4.73) \(I^2\) = 90.2%, P = 0.812
- Left 1.24 (0.21, 7.27) \(I^2\) = 90.2%, P = 0.812

**Location of occlusion**

- ICA: 0.66 (0.45, 0.97) \(I^2\) = 71.7%, P = 0.035
- M1: 1.44 (0.97, 2.15) \(I^2\) = 80.4%, P = 0.072
- M2: 1.12 (0.79, 1.58) \(I^2\) = 0.0%, P = 0.534
- Tandem occlusion: 0.86 (0.34, 2.13) \(I^2\) = 0.0%, P = 0.737
- Ipsilateral AComA and PComA: 0.73 (0.42, 1.24) \(I^2\) = 34.7%, P = 0.243

**Intervention characteristics**

- Time of onset to puncture: 11.36 (−23.38, 46.09) \(I^2\) = 9.0, P = 0.522
- Duration of intervention: −27.85 (−42.11, −13.58) \(I^2\) = 94.1, P < 0.001
- General anesthesia: 0.65 (0.54, 0.80) \(I^2\) = 0.0%, P < 0.001
- Aspiration only: 1.48 (0.69, 3.16) \(I^2\) = 85.2%, P = 0.312
- Stent retriever only: 0.90 (0.55, 1.48) \(I^2\) = 71.7%, P = 0.689
- Aspiration and stent retriever both: 0.67 (0.22, 2.04) \(I^2\) = 93.1%, P = 0.479
- Use of BGC: 1.81 (1.27, 2.59) \(I^2\) = 73.4%, P = 0.001
- Migration to new territory: 0.55 (0.25, 1.22) \(I^2\) = 0.0%, P = 0.142

**FIGURE 4** | Determinants of achieving complete recanalization with FPE. (A) Age; (B) female; (C) ICA.
BGC use has been widely accepted contributing to FPE during thrombectomy procedure (7, 9, 13, 15). One of the reasons may be decreased distal embolization and more importantly increased flow reversal. According to Kang et al. (9), additional positive effects of BGC use were suggested. One is the force needed for clot retrieving, including impaction force and combined force of friction and adhesion between the thrombus and vessel wall. The other is that inflating the BGC can markedly reduce systemic blood pressure on the proximal clot surface and decrease the pressure gradient across the clot.

It is difficult to explain why increased age was found a contributor to successful and complete recanalization after first-pass thrombectomy. One possible reason may be stroke etiology, as elderly patients are more likely to have cardioembolic cause (32). Clots from cardioembolic causes are more likely to be rich in red blood cells whereas thromboembolism due to preexisting atherosclerosis may be rich in fibrin and platelets. Clots composed predominantly of RBCs are considered fresh and less compact, and this may lead to easier recanalization through thrombectomy with first pass (33–37). Also, increased fibrin percentage could decrease the possibility of clot complete retrieval (38, 39). However, heterogeneous results exist among studies and we could not detect a relationship between FPE and stroke etiology, which may be due to limited data.

This study showed that females are more likely to achieve FPE than males. This phenomenon has been described by Zaidat et al. (7). Anatomical, pathophysiological, and biochemical factors may potentially account for observed difference in response to recanalization therapy between sexes (40). In addition, there was a difference of endogenous fibrinolytic activity between males and females (35, 41). Further studies are needed to explore the underlying biochemical interactions which are further felt to change with age/ menopause (42).

Conscious sedation has been associated with better outcomes of MT than general anesthesia in previous researches (43). In this study, we further extended this preference of local anesthesia considering FPE, but the mechanisms remain unknown (17). One hypothesis is a shorter time to reperfusion by conscious sedation (44), as dynamic changes of clot composition found in previous studies, such as fibrin deposition, may increase the risk of re-occlusion (34, 36). However, some studies have mentioned that GA is associated with better outcome than conscious sedation. So, comparison of different anesthesia modalities needs further research (45). At the same time, difference in clot length may be a principal reason for the association between clot location and FPE. It was found that clots in ICA were with longer length and those in M2 segment were with relatively shorter length (7, 17).

There are some limitations of this study. Recruited studies were mostly retrospective with small sample size, and variables observed were not uniform. Some potentially important factors, such as clot volume (13), were only investigated occasionally and thus could not be reliably meta-analyzed. Potential differences may exist between anterior and posterior circulation stroke, and separate analysis may be more valuable. Also, device development could also influence the recanalization outcome, and comparison among different thrombectomy techniques may also be very important. However, it is unable to be analyzed due to high heterogeneity among studies. It remains elusive why DM was a contributor to successful recanalization with FPE (46). Maybe this is caused by bias from limited studies and should be further studied.

**CONCLUSION**

Age, gender, occlusion site, conscious sedation, and use of BGC were factors influencing both successful and complete recanalization after first-pass thrombectomy. Further studies with more comprehensive observational indices are needed to confirm these observations.

**DATA AVAILABILITY STATEMENT**

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author/s.

**AUTHOR CONTRIBUTIONS**

XB, XZ, and LJ developed the initial idea for this study and formulated the study design. YZ, AD, TW, RX, YF, XW, and KY developed and revised the search strategy. LJ, YM, HS, and QM were consulted about clinical issues. XB, XZ, and JW contributed to the original draft. XB, XZ, AD, JW, YZ, TW, LL, KY, YM, HS, QM, and LJ were responsible for the revision of the draft. All authors approved the final version of the manuscript before submission.
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**SUPPLEMENTARY MATERIAL**

The Supplemental Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fneur.2021.628523/full#supplementary-material

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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