



HAL
open science

Rescue Stenting versus Medical Care Alone in Refractory Large Vessel Occlusions: A Systematic Review and Meta-Analysis

Kevin Premat, Agnès Dechartres, Stephanie Lenck, Eimad Shotar, Raphael Le Bouc, Vincent Degos, Nader Sourour, Sonia Alamowitch, Yves Samson, Frédéric Clarençon

► To cite this version:

Kevin Premat, Agnès Dechartres, Stephanie Lenck, Eimad Shotar, Raphael Le Bouc, et al.. Rescue Stenting versus Medical Care Alone in Refractory Large Vessel Occlusions: A Systematic Review and Meta-Analysis. *Neuroradiology*, 2020, 62 (5), pp.629–637. 10.1007/s00234-020-02360-9. hal-03879095

HAL Id: hal-03879095

<https://hal.sorbonne-universite.fr/hal-03879095v1>

Submitted on 15 Mar 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

1 Rescue Stenting versus Medical Care Alone in Refractory Large 2 Vessel Occlusions: a Systematic Review and Meta-Analysis

3
4
5 Kévin Premat, MD ¹, Agnes Dechartres, MD, PhD ², Stéphanie Lenck, MD, MSc ¹, Eimad Shotar, MD, MSc ¹,
6 Raphaël Le Bouc, MD, PhD ³, Vincent Degos, MD, PhD ⁴, Nader Sourour, MD ¹, Sonia Alamowitch, MD, PhD
7 ⁵, Yves Samson, MD ³, Frédéric Clarençon, MD, PhD ¹

8
9 ¹Sorbonne University, AP-HP, Pitié Salpêtrière - Charles Foix Hospital, Department of Interventional
10 Neuroradiology, F75013, Paris, France

11 ²Sorbonne University, INSERM, Pierre Louis Institute of Epidemiology and Public Health, AP-HP, Pitié
12 Salpêtrière - Charles Foix Hospital, Departement of Biostatistics, Public Health and Medical Information,
13 F75013, Paris, France

14 ³Sorbonne University, AP-HP, Pitié Salpêtrière - Charles Foix Hospital, Departement of Vascular Neurology,
15 F75013, Paris, France

16 ⁴Sorbonne University, AP-HP, Pitié Salpêtrière - Charles Foix Hospital, Department of Anesthesiology and
17 Critical Care, F75013, Paris, France

18 ⁵Sorbonne University, AP-HP, Saint Antoine Hospital, Departement of Vascular Neurology, F75012, Paris,
19 France

20
21
22 Corresponding author: Kévin Premat, M.D.

23 Department of Neuroradiology. Pitié-Salpêtrière Hospital,

24 47-83 Boulevard de l'Hôpital, 75013 Paris, France

25 Mail : kevin.premat@aphp.fr

26 Phone: +33142163606

27 Fax: +33142183515

28
29 **Keywords:** Stroke, Thrombectomy, Endovascular Recanalization, Reperfusion

30 **ABSTRACT**

31

32 **Purpose:**

33 Mechanical thrombectomy (MT) failure is associated with very poor prognosis. Permanent intracranial stenting
34 (PIS) may be useful in such refractory occlusions. However, this strategy requires an aggressive antithrombotic
35 regimen that may be harmful in extended strokes. The aim of this study was to compare clinical outcomes
36 between patients with refractory acute large vessel occlusions (LVO) treated by PIS versus patients for whom
37 the procedure was stopped without recanalization.

38 **Methods:**

39 We conducted a systematic review by searching for articles in PubMed, the Cochrane Library and
40 ClinicalTrials.gov from January 2015 to September 2019. Two reviewers independently selected studies
41 comparing PIS after failed MT in addition to usual care versus usual care only. A comparative meta-analysis was
42 performed using random-effects models to estimate odds ratios of favorable clinical outcome at 90 days, defined
43 as a modified Rankin Scale 0-2, mortality and symptomatic intracranial haemorrhage (SICH).

44 **Results:**

45 Four comparative studies were included for a total of 352 patients: 149 in the PIS group versus 203 in the control
46 group. PIS was associated with significantly higher rates of 90-day favorable clinical outcome (Odds Ratio
47 [OR] : 2.87 [95% confidence interval (95% CI) : 1.77-4.66] ; $p < 0.001$; I^2 : 0%) and lower mortality (OR : 0.39
48 [0.16-0.93] ; $p = 0.03$; I^2 : 43%), whereas SICH rates did not significantly differ (OR 0.68 [0.37-1.27] ; $p = 0.23$; I^2 :
49 0%).

50 **Conclusion:**

51 From observational study results, attempting PIS after failed MT seems to improve clinical outcomes without
52 increasing the risk of intracranial bleeding. Randomized trials are needed to confirm these results.

53

54 **INTRODUCTION**

55 Mechanical thrombectomy (MT) for acute ischemic stroke due to large-vessel occlusion (AIS-LVO) is now well
56 established as one of the most efficient treatments in interventional medicine [1, 2]. Indications have greatly
57 expanded in recent years [3, 4], allowing for more patients to benefit from this treatment. However, despite
58 optimized triage and management, a substantial number of patients remains with occlusion or experiences early
59 reocclusion. In randomized trials[1, 5], the rate of MT technical failure, defined as modified thrombolysis in
60 cerebral infarction[6] (mTICI) score IIa or worse, ranges from 10% to 30%, with disastrous consequences in
61 terms of clinical outcomes for these patients[7]. Reasons for MT failure include impossibility to access the target
62 occlusion or, in most cases, failure of clot extraction despite multiple stent retriever or aspiration passes[8–10].

63 Intracranial atherosclerotic disease-related occlusions account for about 25%[11] to 47%[12] of all intracranial
64 LVOs and seem to be particularly involved in MT failure[13]. Current thrombectomy devices may be excellent
65 for embolectomy but less suitable for removing in situ plaque thromboses. They could even be harmful by
66 causing more plaque activation, which may result in early reocclusion[14]. In interventional cardiology, in which
67 this atherosclerotic mechanism is dominant, direct thromboaspiration has been found inefficient in such
68 cases[15]. Thus, intracranial atherosclerotic acute occlusions could be managed like acute coronary occlusions,
69 with early stenting and antithrombotic management. However, there is a potential risk of intracranial bleeding
70 related to an aggressive antithrombotic regimen[16], which may counterbalance the benefit of vessel patency.

71 Before the technological breakthrough of stent retrievers in MT, permanent intracranial stenting (PIS) was
72 regularly used as a first-line technique for AIS-LVO, with an acceptable level of safety[17]. Recently, PIS has
73 been increasingly used as a rescue technique for failed recanalization and opened a new path to improve
74 reperfusion rates and clinical outcomes.[18–24] Recent meta-analysis of proportions suggested that PIS could be
75 a safe and effective rescue technique after failed MT[17, 25], however the level of evidence provided by meta-
76 analysis of proportions is low, as they only focus on the experimental group and thus, do not allow direct
77 comparison to a control group. Yet, whether PIS is superior to medical management alone, in refractory LVO
78 remains unknown. Moreover, a large multicenter propensity-score matched cohort study, which was not
79 integrated in previous meta-analyses, has been recently published[26]. Incorporating this study should strengthen
80 the results that may have game-changing implications for this subset of patients.

81 The aim of this work was to systematically review the literature evaluating the effect of PIS in improving the
82 clinical outcome for patients with refractory LVO in comparison to patients for whom no PIS was attempted and
83 who remained without recanalization.

84

85 MATERIAL AND METHODS

86 This systematic review and meta-analysis was reported according to the Preferred Reporting Items for
87 Systematic Reviews and Meta-Analyses (PRISMA) guidelines[27]. The protocol was registered at PROSPERO
88 (CRD42019133434).

89 Search strategy

90 We conducted an electronic search of MEDLINE via PubMed and the Cochrane Library with the search
91 algorithm reported in **Electronic Supplementary Material**. The search was initially conducted in April 2019,
92 then updated in September 2019. The search was restricted from January 2015, when endovascular treatment for
93 AIS was generally accepted and routinely performed. We also manually searched the table of contents of the 10
94 most implicated journals in endovascular stroke medicine (*Stroke, JAMA Neurology, Journal of*
95 *Neurointerventional Surgery, Journal of Neurosurgery, Clinical Neuroradiology, Journal of Neuroradiology,*
96 *Interventional Neuroradiology, International Journal of Stroke, Journal of Stroke Cerebrovascular Diseases*
97 *and European Journal of Neurology*) for any additional reference. A search in ClinicalTrials.gov was also
98 performed and the reference lists of eligible full-text manuscripts were checked for additional references.

99 Eligibility criteria and selection process

100 The following inclusion criteria were defined before reviewing: 1) studies comparing patients who underwent
101 PIS in the 48 hr after an ischemic stroke with LVO and after at least one MT attempt to patients receiving only
102 usual care for refractory occlusions; 2) peer-reviewed publication as stated by the journal; 3) minimum of 5
103 patients included; and 4) available modified Rankin Scale (mRS) score at 90 days. Exclusion criteria were 1)
104 lack of a control group, 2) tandem (extracranial + intracranial) occlusions, 3) non-English language, 4) non-
105 human study, and 5) inclusion period before the standard use of stent retrievers in MT. When several articles
106 originated from the same center and included overlapping populations, only the most relevant article with the
107 largest population was retained. Two reviewers independently evaluated eligibility criteria for all references
108 retrieved by the search. Any disagreements were discussed to achieve consensus.

109 Data extraction

110 Two investigators independently extracted data for each included study from full texts, figures, tables and
111 supplemental materials if available. Any disagreements were discussed to achieve consensus. The following data
112 were extracted:

- 113 • Publication characteristics: year of publication and journal.
- 114 • Study design: randomized trial, prospective or retrospective cohort, case-control study and sample size.
- 115 • Patient baseline characteristics: sex, age, past medical history, National Institute of Health Stroke Scale
116 (NIHSS) score at admission, initial Alberta Stroke Program Early Computed Tomography (ASPECT)
117 score and use of intravenous tissue plasminogen activator (IV-tPA).

- 118 • Procedural parameters: number of MT attempts (with a stent retriever or direct thromboaspiration),
119 antithrombotic management and other rescue interventions besides stenting.
- 120 • Outcomes of interest: favorable clinical outcome defined as a mRS score 0 to 2 at 90 days, defined as
121 the primary outcome; successful reperfusion; mortality; and SICH as defined in the European
122 Cooperative Acute Stroke Study[28]. For each outcome of interest, we collected the corresponding
123 number of events in each group and the number of patients analyzed in each group.

124 **Risk of bias assessment**

125 Risk of bias was evaluated by both reviewers by using the Newcastle–Ottawa Quality Assessment Form for
126 Cohort and Case-control Studies[29]. Any disagreements were discussed to achieve consensus.

127 **Statistical analysis**

128 All continuous data are described with means (SD) or medians (quartile 1 [Q1]–Q3 or range) and qualitative data
129 with frequencies (%). Associations between PIS and outcomes are expressed as odds ratios (ORs) and 95%
130 confidence intervals (CIs). We first evaluated characteristics of included studies to assess whether they were
131 sufficiently close to allow meta-analyses We conducted random-effects meta-analyses considering the presumed
132 heterogeneity of the included studies. However, a sensitivity analysis with fixed-effect models was performed.
133 For each meta-analysis, heterogeneity was evaluated with the Cochran Q and I² statistics and the between-study
134 variance τ^2 . We planned to perform evaluation of small study effects including publication bias using funnel
135 plots and Egger tests but this was not possible because of the low number of identified studies. For all analyses,
136 $p < 0.05$ was considered statistically significant. Meta-analyses were performed with Review Manager (RevMan)
137 v5.3 (Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014). For zero events, Revman
138 automatically applies a correction for trials with 0 in one arm only. The correction consists in adding 0.5 to each
139 of the cells of the 2x2 table to calculate odds ratios.

140 RESULTS

141 Selection process

142 In total, 1168 records were identified by the search and were screened for eligibility. After initial screening, 25
143 were considered for full-text review (**Figure 1**) and finally, 4 comparative studies (352 patients) were included.

144 Study characteristics

145 **Table 1** summarizes the characteristics of each included study. Briefly, the Baracchini et al.[19] study was a
146 prospective single-center cohort study performed from 2014 to 2016 that included 109 patients who underwent
147 stent retriever thrombectomy and were divided into 4 groups: 1) successful reperfusion, 2) successful reperfusion
148 after rescue intra-arterial tirofiban infusion only, 3) PIS after failed MT, and 4) no successful reperfusion. Only
149 data from groups 3 and 4 were considered for this meta-analysis. The Chang et al.[20] study was a large
150 multicenter prospective cohort study including 148 patients with MT failure who received rescue stenting or no
151 rescue stenting. The Cornelissen et al.[21] study was a retrospective single-center cohort study that compared
152 outcomes in 26 patients included after failed clot extraction attempts with the Embotrap device, who received
153 PIS or remained with persistent LVO. Finally, the Peng et al.[26] study was a multicenter retrospective cohort
154 study that initially included 90 consecutive patients in the rescue stenting group and 117 patients in the control
155 group. However, considering that both groups were not exactly comparable, and especially for crucial
156 parameters such as baseline NIHSS and ASPECT scores, authors performed a propensity score matching in
157 order to obtain the best balance possible. After propensity score matching, 66 patients were included in each
158 group; and we used the data from this matched population in this meta-analysis.

159 The methodological quality of included studies was judged “fair” and “good” according to the Newcastle–
160 Ottawa Quality Assessment Form.

161 Baseline characteristics

162 Of the 352 patients included in analysis, 149 underwent PIS after failed MT attempts (PIS group) and 203 did
163 not undergo rescue stenting (control group). All recorded baseline characteristics, including major confounding
164 factors such as NIHSS score at admission, use of IV-tPA or site of occlusion, were similar between the two
165 groups (**Table 1**). Only one study included patients with posterior circulation occlusions. The 4 studies used a
166 wide variety of antithrombotic protocols and different types of interventions before and after stenting, that were
167 summarized in **Table 2**. Of note, only the studies of Chang et al.[20] and Peng et al.[26] gave detailed
168 informations regarding additional interventions during the procedures for the PIS and the control groups
169 altogether.

170 Outcomes

171 Favorable clinical outcome at 90 days was significantly more frequent in the PIS than control group (OR, 2.87;
172 95% CI, 1.77-4.66), with low heterogeneity across studies ($p_{\text{het}}=0.41$, $I^2 = 0\%$, $\tau^2 = 0.00$) (**Figure 2**). Mortality
173 was significantly lower in the PIS group (OR, 0.39; 95% CI, 0.16-0.93; $I^2 = 43\%$) but SICH rates did not

174 significantly differ between the groups (OR, 0.68; 95% CI, 0.37-1.27; $I^2 = 0\%$). Sensitivity analyses with fixed-
175 effects models gave consistent results, except for mortality. Successful mTICI \geq IIb reperfusion rates after rescue
176 stenting ranged from 64.6% to 91.7%.

177

178 **Delays**

179 Times from symptoms' onset to arterial puncture were similar between both groups across studies and ranged
180 from an average of 196.1 (+/- 48.1) to 289 minutes (+/- 90.9). Two studies specifically evaluated the delays from
181 arterial puncture to successful recanalization after stenting and found an average of 113 (+/- 53) minutes in the
182 Chang et al.[20] study and 83.3 (+/- 50.1) minutes in the study of Cornelissen et al.[21]

183

184 DISCUSSION

185 The interest over PIS as a rescue technique after failed MT is rapidly growing[17, 19–21, 25], owing to the
186 positive clinical findings in everyday practice. Even though, no randomized controlled trials have been
187 conducted so far, several comparative observational studies have been published. Of note, a recent and the
188 largest one to date, is a multicenter Chinese cohort study[26] that performed a propensity-score matching, which
189 is the most robust pairing method for observational studies, that limits indication bias to its minimum and
190 provides top-level comparability. The results of this study were in line with previous comparative studies and
191 were incorporated in this meta-analysis. Our current meta-analysis includes studies comparing clinical outcomes
192 of rescue PIS to no additional endovascular interventions. PIS was associated with improved clinical outcome at
193 90 days and lower mortality as compared with no recanalization. Although PIS requires an aggressive
194 antiplatelet regimen (**Table 2.**) to ensure stent patency, it did not seem to result in increased rates of SICH.

195 Refractory LVO remains a major concern in the era of MT because it is associated with an unfavorable
196 prognosis as confirmed by data from the control groups in our included studies. After an average of 3.5
197 intracranial MT passes, successful reperfusion could never be achieved, and persistent occlusion was confirmed
198 at the end of procedures in all studies (0% of mTICI \geq IIB in the control groups). Rates of functional
199 independence at 90 days ranged from 17.4% to 22% and mortality rates from 19% to 43.9%. These rates are
200 consistent with data from patients included in the control arms of the 5 first randomized trials evaluating MT[1].
201 In comparison, attempting PIS permitted successful reperfusion of most refractory LVOs, resulting in an
202 increased rate of favorable clinical outcome, more in line with those expected in the general setting of MT. The
203 more MT is attempted, the less probability of achieving reperfusion, which leads to deteriorated clinical
204 outcomes. Some observational studies have even suggested that beyond 5 attempts, the probability of achieving
205 reperfusion decreases drastically and that, even when achieved, does not result in improved outcomes when
206 compared to patients without recanalization. [30] This finding suggests that if PIS is considered, it should be
207 promptly initiated to avoid futile recanalization that could be detrimental to patients under dual antiplatelet
208 therapy.

209 As expected, SICH rates in these studies were high, about three-fold higher than in the HERMES pooled
210 population[1]. Indeed, MT failure is a well-known risk factor for SICH[31] and in many PIS cases,
211 antglycoprotein IIb/IIa agents were used before stenting, which also have known risks for haemorrhagic
212 transformations, especially in extended stroke. Even though the level of evidence is low, we did not observe an
213 additional risk in patients receiving PIS as compared with the control group. However, this observation should
214 be carefully interpreted since additional IA antithrombotics were also used in the control groups which may have
215 overestimated the rates of SICHs. Moreover, the included studies mostly used CT-based protocols when AIS was
216 suspected, which may not be the best way to evaluate the extent of infarctions, especially at the hyperacute
217 phase. The two largest studies provided an estimation of the infarction volume using the ASPECT score; and
218 these ASPECTs were rather high in patients included. This suggests that patients from these studies were
219 selected for rescue stenting with special attention to this parameter; and that if PIS was to be performed in lower
220 ASPECT groups, SICHs would probably be more frequent. As such, the initial volume of infarction should be
221 viewed as a critical factor to consider before placing a patient under strong antiplatelet therapy in the setting of

222 PIS. Furthermore, the featured studies included AIS within 6 hours from symptoms' onset to puncture; therefore
223 these results may only be applicable to this subset of patients and not to late-onset strokes. Studies that disclosed
224 the times from puncture to reperfusion when PIS was performed showed that these procedures were rather long,
225 which is a natural consequence of the refractory nature of these occlusions. Longer procedures did not result in
226 worse outcomes or increased SICHs in the PIS group; however one must consider that beyond 6 hours from
227 symptoms onset, PIS has not yet been sufficiently studied, and could arguably be harmful by promoting SICHs
228 in late infarcts.

229 Within each study, baseline characteristics of patients did not differ between those with PIS and those without
230 recanalization. These populations also seemed quite comparable to the population included in the 5 main
231 randomized trials of MT[1]. Although the reports lacked information regarding the AIS etiology, a fair
232 proportion probably resulted from intracranial atherosclerotic disease, especially considering the over-
233 representation of the Asian patient population in this meta-analysis[20, 26].

234 This study has several limitations. First, the small sample size of included studies and the observational design
235 intrinsically limit the level of evidence. Although the groups were comparable, we cannot exclude confounding
236 or indication bias because the decision to undergo PIS was solely at the operator's discretion and was not
237 protocol-based. No information was available regarding the parameters used for patient selection and specifically
238 infarct size and how this was integrated in decision-making for intracranial stenting. Another limitation is related
239 to the high heterogeneity in antithrombotic management across studies and other interventions besides PIS such
240 as balloon angioplasty.

241 Nevertheless, this comparative meta-analysis of observational studies provides additional evidence to answer the
242 question of whether the benefit of vessel patency through rescue stenting outweighs the risk of intracranial
243 haemorrhage in refractory LVOs.

244

245 **CONCLUSION**

246 Although the prevalence of refractory LVO is decreasing in the modern era of MT with improved techniques, the
247 prognosis remains unfavorable. PIS may be an efficient rescue technique, allowing for important improvements
248 in clinical outcome in this subgroup of patients. Although PIS requires strong antithrombotic therapy, no
249 differences in SICHs were found between groups. However, given the level of evidence, decisions to undergo
250 the procedure should be carefully evaluated and on a patient-level basis, with special attention to the extent of
251 infarction before stenting as well as the delay from symptoms' onset. This work warrants randomized studies to
252 confirm these assumptions and identify the patients who could benefit most from these findings.

253

254 **COMPLIANCE WITH ETHICAL STANDARDS**

255

256 **Funding:** None

257

258 **Conflict of Interest:** The author declares conflicts of interests.

259 Dr. Sourour reports a conflict of interest with Medtronic, Balt Extrusion, Microvention (consultant), Stock/Stock

260 Options: Medina. Prof. Clarençon reports a conflict of interest with Medtronic, Guerbet, Balt Extrusion

261 (payment for readings), Codman Neurovascular (core lab). The other authors report no conflicts of interest.

262

263 **Ethical approval:** For this type of study formal consent is not required.

264

265 **Informed consent:** Not required

266

267

268

269 REFERENCES

- 270 1. Goyal M, Menon BK, van Zwam WH, et al (2016) Endovascular thrombectomy after large-vessel
271 ischaemic stroke: a meta-analysis of individual patient data from five randomised trials. *Lancet Lond Engl*
272 387:1723–1731. [https://doi.org/10.1016/S0140-6736\(16\)00163-X](https://doi.org/10.1016/S0140-6736(16)00163-X)
- 273 2. Powers WJ, Rabinstein AA, Ackerson T, et al (2018) 2018 Guidelines for the Early Management of
274 Patients With Acute Ischemic Stroke: A Guideline for Healthcare Professionals From the American Heart
275 Association/American Stroke Association. *Stroke* 49:e46–e110.
276 <https://doi.org/10.1161/STR.000000000000158>
- 277 3. Albers GW, Marks MP, Kemp S, et al (2018) Thrombectomy for Stroke at 6 to 16 Hours with Selection by
278 Perfusion Imaging. *N Engl J Med* 378:708–718. <https://doi.org/10.1056/NEJMoa1713973>
- 279 4. Nogueira RG, Jadhav AP, Haussen DC, et al (2018) Thrombectomy 6 to 24 Hours after Stroke with a
280 Mismatch between Deficit and Infarct. *N Engl J Med* 378:11–21. <https://doi.org/10.1056/NEJMoa1706442>
- 281 5. Lapergue B, Blanc R, Gory B, et al (2017) Effect of Endovascular Contact Aspiration vs Stent Retriever
282 on Revascularization in Patients With Acute Ischemic Stroke and Large Vessel Occlusion: The ASTER
283 Randomized Clinical Trial. *JAMA* 318:443–452. <https://doi.org/10.1001/jama.2017.9644>
- 284 6. Zaidat OO, Yoo AJ, Khatri P, et al (2013) Recommendations on angiographic revascularization grading
285 standards for acute ischemic stroke: a consensus statement. *Stroke* 44:2650–2663.
286 <https://doi.org/10.1161/STROKEAHA.113.001972>
- 287 7. Kim GE, Yoon W, Kim SK, et al (2016) Incidence and Clinical Significance of Acute Reocclusion after
288 Emergent Angioplasty or Stenting for Underlying Intracranial Stenosis in Patients with Acute Stroke.
289 *AJNR Am J Neuroradiol* 37:1690–1695. <https://doi.org/10.3174/ajnr.A4770>
- 290 8. Kaesmacher J, Gralla J, Mosimann PJ, et al (2018) Reasons for Reperfusion Failures in Stent-Retriever-
291 Based Thrombectomy: Registry Analysis and Proposal of a Classification System. *AJNR Am J*
292 *Neuroradiol* 39:1848–1853. <https://doi.org/10.3174/ajnr.A5759>
- 293 9. Hashimoto T, Hayakawa M, Funatsu N, et al (2016) Histopathologic Analysis of Retrieved Thrombi
294 Associated With Successful Reperfusion After Acute Stroke Thrombectomy. *Stroke* 47:3035–3037.
295 <https://doi.org/10.1161/STROKEAHA.116.015228>
- 296 10. Hwang Y-H, Kim Y-W, Kang D-H, et al (2016) Impact of Target Arterial Residual Stenosis on Outcome
297 After Endovascular Revascularization. *Stroke* 47:1850–1857.
298 <https://doi.org/10.1161/STROKEAHA.116.013046>
- 299 11. Tsang ACO, Orru E, Klostranec JM, et al (2019) Thrombectomy Outcomes of Intracranial
300 Atherosclerosis-Related Occlusions. *Stroke* 50:1460–1466.
301 <https://doi.org/10.1161/STROKEAHA.119.024889>
- 302 12. Wang Y, Zhao X, Liu L, et al (2014) Prevalence and outcomes of symptomatic intracranial large artery
303 stenoses and occlusions in China: the Chinese Intracranial Atherosclerosis (CICAS) Study. *Stroke* 45:663–
304 669. <https://doi.org/10.1161/STROKEAHA.113.003508>
- 305 13. Li H, Zhang Y, Zhang L, et al (2019) Endovascular Treatment of Acute Ischemic Stroke Due to
306 Intracranial Atherosclerotic Large Vessel Occlusion. *Clin Neuroradiol*. <https://doi.org/10.1007/s00062-019-00839-4>
- 308 14. Mosimann PJ, Kaesmacher J, Gautschi D, et al (2018) Predictors of Unexpected Early Reocclusion After
309 Successful Mechanical Thrombectomy in Acute Ischemic Stroke Patients. *Stroke* 49:2643–2651.
310 <https://doi.org/10.1161/STROKEAHA.118.021685>

- 311 15. Watanabe H, Shiomi H, Nakatsuma K, et al (2015) Clinical efficacy of thrombus aspiration on 5-year
312 clinical outcomes in patients with ST-segment elevation acute myocardial infarction undergoing
313 percutaneous coronary intervention. *J Am Heart Assoc* 4:e001962.
314 <https://doi.org/10.1161/JAHA.115.001962>
- 315 16. Abdenmour L, Sourour N, Drir M, et al (2019) Preliminary Experience with Cangrelor for Endovascular
316 Treatment of Challenging Intracranial Aneurysms. *Clin Neuroradiol*. <https://doi.org/10.1007/s00062-019-00811-2>
317
- 318 17. Wareham J, Flood R, Phan K, et al (2019) A systematic review and meta-analysis of observational
319 evidence for the use of bailout self-expandable stents following failed anterior circulation stroke
320 thrombectomy. *J Neurointerventional Surg* 11:675–682. <https://doi.org/10.1136/neurintsurg-2018-014459>
- 321 18. Baek J-H, Kim BM, Kim DJ, et al (2016) Stenting as a Rescue Treatment After Failure of Mechanical
322 Thrombectomy for Anterior Circulation Large Artery Occlusion. *Stroke* 47:2360–2363.
323 <https://doi.org/10.1161/STROKEAHA.116.014073>
- 324 19. Baracchini C, Farina F, Soso M, et al (2017) Stentriever Thrombectomy Failure: A Challenge in Stroke
325 Management. *World Neurosurg* 103:57–64. <https://doi.org/10.1016/j.wneu.2017.03.070>
- 326 20. Chang Y, Kim BM, Bang OY, et al (2018) Rescue Stenting for Failed Mechanical Thrombectomy in
327 Acute Ischemic Stroke: A Multicenter Experience. *Stroke* 49:958–964.
328 <https://doi.org/10.1161/STROKEAHA.117.020072>
- 329 21. Cornelissen, S.A., Andersson, T., Holmberg, A. et al (2019) Intracranial Stenting after Failure of
330 Thrombectomy with the emboTrap® Device. *Clin Neuroradiol* 29, 677–683. <https://doi:10.1007/s00062-018-0697-x>
331
- 332 22. Woo HG, Sunwoo L, Jung C, et al (2018) Feasibility of Permanent Stenting with Solitaire FR as a Rescue
333 Treatment for the Reperfusion of Acute Intracranial Artery Occlusion. *AJNR Am J Neuroradiol* 39:331–
334 336. <https://doi.org/10.3174/ajnr.A5477>
- 335 23. Yoon W, Kim SK, Park MS, et al (2015) Endovascular treatment and the outcomes of atherosclerotic
336 intracranial stenosis in patients with hyperacute stroke. *Neurosurgery* 76:680–686; discussion 686.
337 <https://doi.org/10.1227/NEU.0000000000000694>
- 338 24. Zhou T, Li T, Zhu L, et al (2018) Intracranial Stenting as a Rescue Therapy for Acute Ischemic Stroke
339 After Stentriever Thrombectomy Failure. *World Neurosurg* 120:e181–e187.
340 <https://doi.org/10.1016/j.wneu.2018.08.002>
- 341 25. Maingard J, Phan K, Lamanna A, et al (2019) Rescue intracranial stenting following failed mechanical
342 thrombectomy for acute ischaemic stroke: a systematic review and meta-analysis. *World Neurosurg*.
343 <https://doi.org/10.1016/j.wneu.2019.08.192>
- 344 26. Peng F, Wan J, Liu W, et al (2019) Efficacy and safety of rescue stenting following failed mechanical
345 thrombectomy for anterior circulation large vessel occlusion: propensity score analysis. *J*
346 *NeuroInterventional Surg* neurintsurg-2019-015154. <https://doi.org/10.1136/neurintsurg-2019-015154>
- 347 27. Liberati A, Altman DG, Tetzlaff J, et al (2009) The PRISMA Statement for Reporting Systematic Reviews
348 and Meta-Analyses of Studies That Evaluate Health Care Interventions: Explanation and Elaboration.
349 *PLOS Med* 6:e1000100. <https://doi.org/10.1371/journal.pmed.1000100>
- 350 28. Hacke W, Kaste M, Bluhmki E, et al (2008) Thrombolysis with alteplase 3 to 4.5 hours after acute
351 ischemic stroke. *N Engl J Med* 359:1317–1329. <https://doi.org/10.1056/NEJMoa0804656>
- 352 29. The Newcastle–Ottawa Scale (NOS) for Assessing the Quality of Non-Randomized Studies in Meta-
353 Analysis | Request PDF. In: ResearchGate.
354 [https://www.researchgate.net/publication/261773681_The_Newcastle-](https://www.researchgate.net/publication/261773681_The_Newcastle-Ottawa_Scale_NOS_for_Assessing_the_Quality_of_Non-Randomized_Studies_in_Meta-Analysis)
355 [Ottawa_Scale_NOS_for_Assessing_the_Quality_of_Non-Randomized_Studies_in_Meta-Analysis](https://www.researchgate.net/publication/261773681_The_Newcastle-Ottawa_Scale_NOS_for_Assessing_the_Quality_of_Non-Randomized_Studies_in_Meta-Analysis).
356 Accessed 9 Feb 2019

357 30. Baek J-H, Kim BM, Heo JH, et al (2018) Number of Stent Retriever Passes Associated With Futile
358 Recanalization in Acute Stroke. *Stroke* 49:2088–2095. <https://doi.org/10.1161/STROKEAHA.118.021320>

359 31. Hao Y, Yang D, Wang H, et al (2017) Predictors for Symptomatic Intracranial Hemorrhage After
360 Endovascular Treatment of Acute Ischemic Stroke. *Stroke* 48:1203–1209.
361 <https://doi.org/10.1161/STROKEAHA.116.016368>

362

363 **TABLE AND FIGURE LEGENDS**

364 **Figure 1.** Flowchart of the selection of articles.

365 MT: mechanical thrombectomy; mRS: modified Rankin Scale

366

367 **Figure 2.** Forest plots for favorable clinical outcome (modified Rankin Scale score 0–2) at 90 days, mortality
368 and symptomatic intracranial haemorrhage (SICH)

369 Barrachini 2017[19] ; Chang 2018[20] ; Cornelissen[21] ; Peng[26] ; 95% CI : 95% Confidence Interval ; M-H :
370 Mantel-Haenszel

371

372 **Table 1.** Summary of the included study characteristics and main baseline characteristics of included patients
373 with permanent intracranial stenting (PIS group) or usual care (control group)

374 SD: standard deviation ; NIHSS: National Institute of Health Stroke Scale ; ICA: internal carotid artery ; IQR:
375 interquartile range ; MCA: middle cerebral artery ; M1: first segment of the MCA ; M2: second segment of the
376 MCA ; IV-tPA: intravenous tissue plasminogen activator ; ASPECT: Alberta Stroke Program Early Computed
377 Tomography Score ; mL: milliliter.

378

379 **Table 2.** Summary of additional interventions and antithrombotic protocols used in included studies.

380 IA: intra-arterial; IV: intravenous; †: Timing of additional interventions (before or after stenting) not disclosed;
381 rtPA: recombinant tissue plasminogen activator, *No information regarding these additional interventions were
382 available for the control group

383

384 **Table 1.** Summary of the included study characteristics and main baseline characteristics of included patients with permanent intracranial
 385 stenting (PIS group) or usual care (control group)

Study	Country	Period of inclusion	Study design	Number of patients in each group	Main baseline characteristics of patients in the PIS and control groups
Baracchini et al. 2017	Italy	2014-2016	Prospective single-center cohort study	PIS group: 23 Control group: 23	Mean age, years (SD): 70 (16.9) vs 74 (8.3) Median NIHSS score (range): 16 (4-26) vs 18 (5-20) Occlusion site: intracranial ICA and/or MCA in all cases IV-tPA, No. (%): 4/23 (17.4%) vs 10/23 (43.5%)
Chang et al. 2018	South Korea	2010-2015	Prospective multicenter cohort study	PIS group: 48 Control group: 100	Mean age, years (SD): 63.7 (16.8) vs 68.0 (12.1) Median NIHSS score (IQR): 14 (8) vs 15 (6) Median ASPECT score (+/-IQR): 8 (1.75) vs 8 (2) Occlusion site: intracranial ICA and/or MCA in all cases IV-tPA, No. (%): 22/48 (45.8%) vs 46/100 (46.0%)
Cornelissen et al. 2018	Sweden	2013-2017	Retrospective single-center cohort study	PIS group: 12 Control group: 14	Mean age, years (SD): 65.2 (13.9) vs 67.3 (9.5) Median NIHSS score (range): 16.5 (5–22) vs 16.5 (8–22) Infarct volume, mL (SD): 14.9 (22.3) vs 30.1 (36)

					<p>Occlusion site: No. (%):</p> <ul style="list-style-type: none"> • PIS group: basilar: 2/12 (16.7%), vertebral: 1/12 (8.3%), ICA: 1/12 (8.3%), M1: 8/12 (66%) • Control group: basilar: 4/14 (28.6%), M1: 9/14 (64.3%), M2: 1/14 (7.1%) <p>IV-tPA, No. (%): 3/12 (25%) vs 6/14 (42.9%)</p>
Peng et al. 2019	China	2015-2018	Retrospective multicenter case-control study	PIS group: 66 Control group: 66	<p>Median age, (IQR): 66 (55-76) vs 67 (56-75)</p> <p>Median NIHSS score (IQR): 16 (12-21) vs 18 (13-21)</p> <p>Median ASPECT score (IQR): 9 (8-10) vs 9 (8-10)</p> <p>Occlusion site: intracranial ICA and/or MCA in all cases</p> <p>IV-tPA, No. (%): 20/66 (30.3%) vs 22/66 (33.3%)</p>

386 SD: standard deviation ; NIHSS: National Institute of Health Stroke Scale ; ICA: internal carotid artery ; IQR: interquartile range ; MCA: middle
387 cerebral artery ; M1: first segment of the MCA ; M2: second segment of the MCA ; IV-tPA: intravenous tissue plasminogen activator ; ASPECT:
388 Alberta Stroke Program Early Computed Tomography Score ; mL: milliliter.

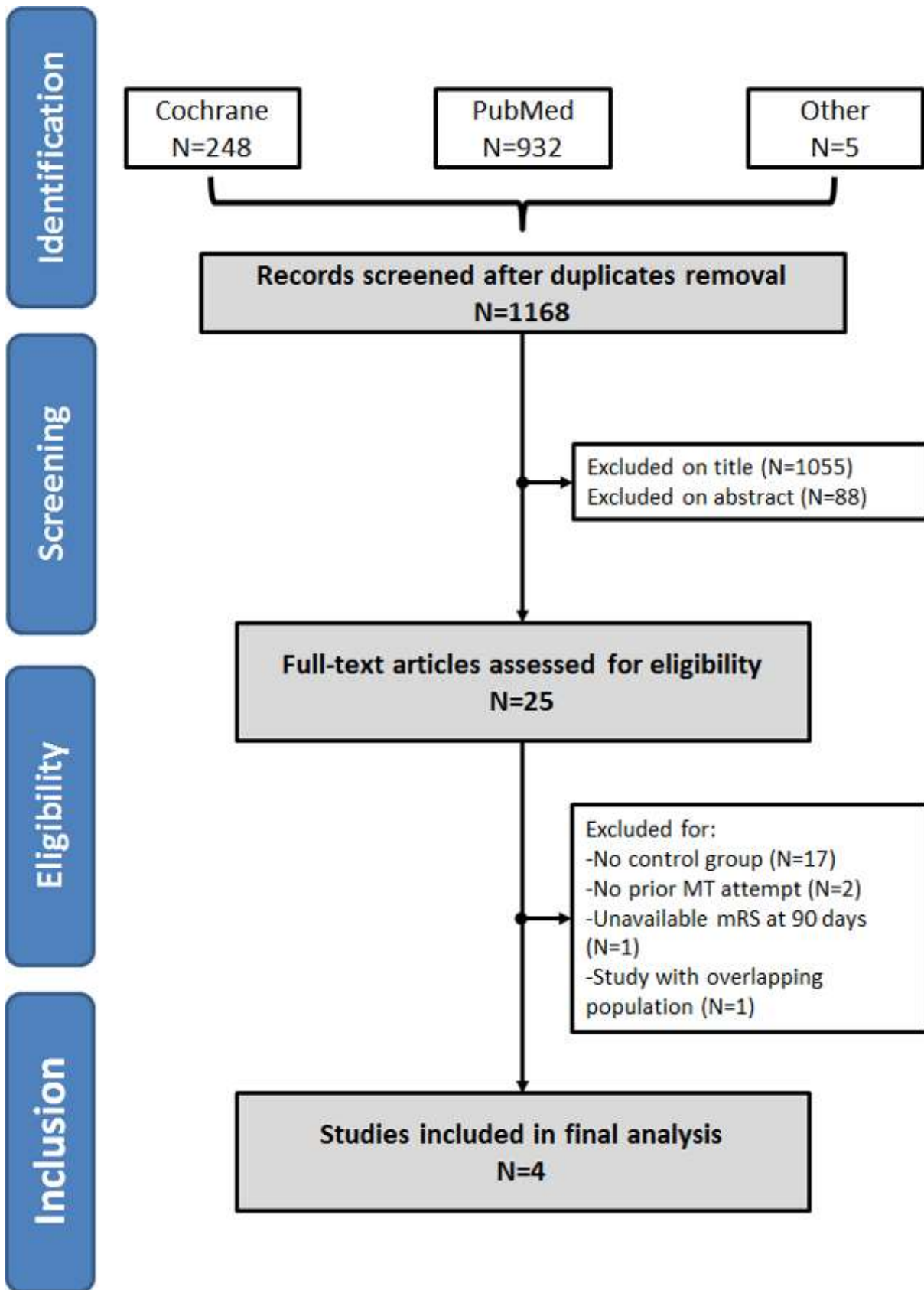
389 **Table 2.** Summary of additional interventions and antithrombotic protocols used in included studies.

Study names	Additional interventions before stenting	Antithrombotic protocol before stenting	Additional interventions after stenting	Antithrombotic regimen after stenting
Baracchini et al. 2017*	Balloon angioplasty IA antiglycoprotein IIb/IIIa	IA bolus (25 µg/kg in 3 min) of antiglycoprotein IIb/IIIa (tirofiban)	Balloon angioplasty for residual stenosis	12-hr IV infusion (0.1 µg/kg/min) of tirofiban then switch to dual antiplatelet therapy for 3 months
Chang et al. 2018	†Balloon angioplasty: 15/48 (31.3%) in PIS group versus 4/100 (4%) in control group IA antiglycoprotein IIb/IIIa: 34/48 (70.8%) in PIS group versus 14/100 (14%) in control group IA urokinase : 7/48 (14.6%) in PIS group versus 16/100 (16%) in control group			Not available
Cornelissen et al. 2018*	None	IV bolus of antiglycoprotein IIb/IIIa (abiximab) or aspirin	Balloon angioplasty	Dual antiplatelet therapy for 3–6 months then aspirin for life
Peng et al. 2019	†Balloon angioplasty: 18/66 (27.3%) in PIS group versus 20/66 (30.3%) in control group IA Tirofiban: 18/66 (27.3%) in PIS group versus 16/66 (24.2%) in control group IA urokinase or rtPA: 7/66 (10.6%) in PIS group versus 5/66 (7.6%) in control group			Not available; At the operator's discretion

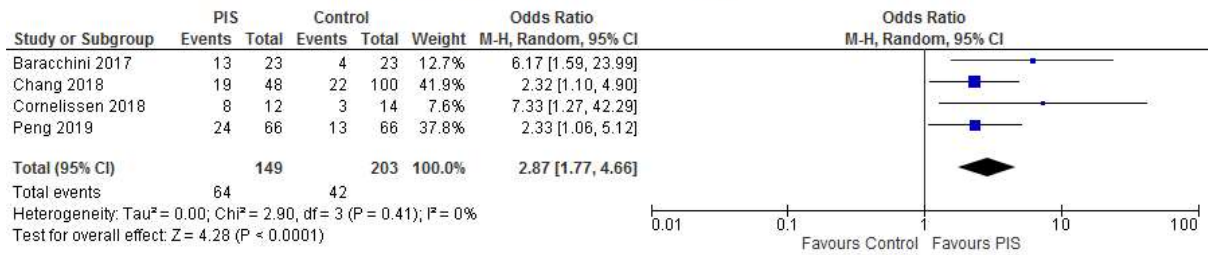
390 IA: intra-arterial; IV: intravenous; †: Timing of additional interventions (before or after stenting) not disclosed; rtPA: recombinant tissue

391 plasminogen activator; *No information regarding these additional interventions were available for the control group

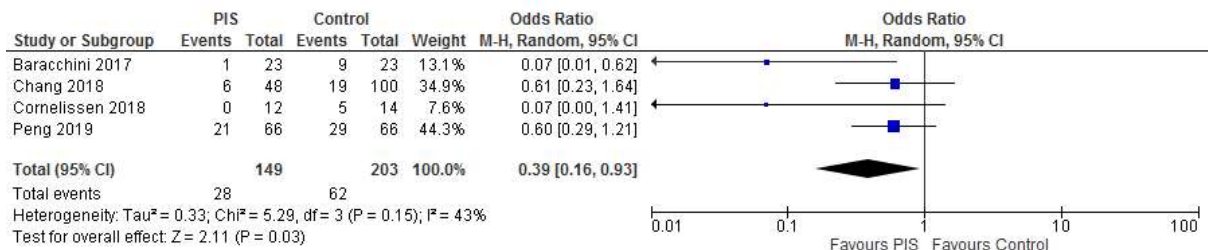
392



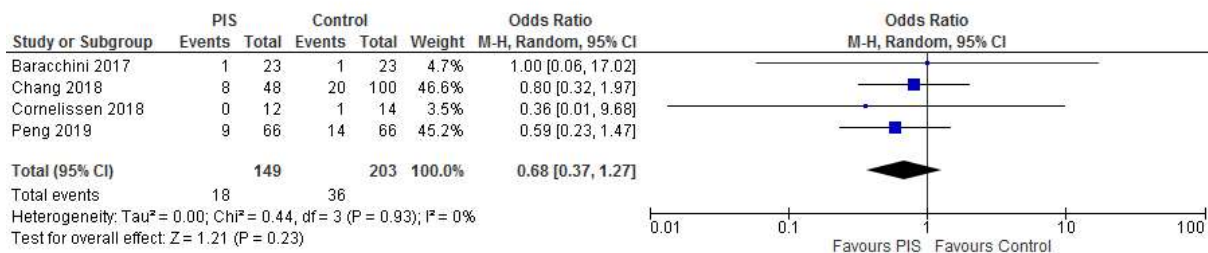
modified Rankin Scale 0-2 at 90 days



Mortality



Symptomatic Intracranial Haemorrhage



396

397