Cerebrovascular Diseases

Stroke Spectrum

Cerebrovasc Dis
DOI: 10.1159/000529265

Received: November 18, 2022
Accepted: January 17, 2023
Published online: March 23, 2023

The Effect of Mechanical Thrombectomy on the Incidence of Poststroke Cognitive Impairment: A Systematic Review of Inhomogeneous Literature

Gianluca De Rubeis[a] Sherief Ghozy[b] Sebastiano Fabiano[a] Enrico Pampana[a] Giuseppe Lanzino[c] Luca Saba[d] David F. Kallmes[b]

[a]Department of Diagnostic, UOC of Diagnostic and Interventional Neuroradiology, San Camillo-Forlanini Hospital, Rome, Italy; [b]Department of Radiology, Mayo Clinic, Rochester, MN, USA; [c]Department of Neurosurgery, Mayo Clinic, Rochester, MN, USA; [d]Department of Medical Imaging, Azienda Ospedaliero Universitaria (A.O.U.) of Cagliari-Polo di Monserrato, Cagliari, Italy

Keywords
Ischemic stroke · Thrombectomy · Dementia · Systematic review

Abstract

Introduction: The aim of this study was to evaluate the effect of mechanical thrombectomy (MT) on the incidence of poststroke cognitive impairment (PSCI) in anterior circulation stroke. ***Methods:*** Literature research was performed on PubMed/OVID/Cochrane CENTRAL for studies published in 2015–2022. A review of the references of the included papers was performed for further eligible articles. Clinical characteristics, NIHSS, dementia tests, and outcomes were recorded. The exclusion criteria were nonhuman and non-English. Studies qualities were assessed with MINORS/RoB2 and GRADE. A meta-analysis was performed using the standardized mean difference (Cohen's d) to measure effect size. ***Results:*** Four studies were included in the systematic review after screening 749 articles. No significant differences were found for age and gender (years: 66.70 ± 11.14 vs. 67.59 ± 10.11, $p = 0.37$; male 53.8% vs. 56.4%, $p = 0.57$). MT patients had a more severe stroke than that of the control group (NIHSS: 14.70 ± 4.31 vs. 11.17 ± 4.12; $p < 0.0001$). The control group consisted of medical therapy-alone patients in all studies. I^2 was 76.95%, and Q was 43.4%. MT patients have better performance in overall cognition ($d = 0.33$ [0.074–0.58]) and in several cognitive domains than in the control group (TMT-A, $d = 0.37$ [0.04–0.70]; TMT-B, $d = 0.35$ [0.12–0.58]; digit span test [backward], $d = 0.61$ [0.18–1.06]; colored progressive matrices, $d = 0.48$ [0.05–0.91]; Stroop test [word reading], $d = 0.60$ [0.17–1.03]; color naming, $d = 0.51$ [0.08–0.94]; Rey-Osterrieth Complex Figure [immediate recall], $d = 0.79$ [0.35–1.23]; Rey Auditory Verbal Learning Test [immediate recall], $d = 0.79$ [0.36–1.23]; delayed recall, $d = 0.46$ [0.035–0.89]; and MOCA, $d = 0.46$ [–0.04 to 0.96]). Medical therapy patients had a higher score in coping strategy than MT patients (COPE-28 acceptance, $d = -1.00$ [–1.53 to –0.48]). ***Conclusions:*** The incidence of PSCI is lower in MT patients than in the control group.

Karger@karger.com
www.karger.com/ced

Correspondence to:
Gianluca De Rubeis, derubeis.gianluca@gmail.com

Karger

Introduction

Ischemic stroke is one of the leading causes of disability in Western countries and the second cause of death [1, 2]. However, the age-standardized death rate due to stroke decreased by 36.2% from 1990 to 2016, with a corresponding increase in disability-adjusted life years [3]. Mechanical thrombectomy (MT) is now an established and effective therapy in patients with acute ischemic stroke [4].

The National Institute of Health Stroke Scale (NIHSS) is widely accepted as the main score system for assessing stroke severity, although several limitations are known [5]. However, this scale does not accurately evaluate a patient's coordination, gait impairment, cortical sensory function, distal motor function, memory, and cognition [6]. The incidence of poststroke dementia at 1 year is 34.4% (95% confidence interval [CI]: 29.7–41.5) in patients with a stroke NIHSS score >10 [7]. Furthermore, greater acute declines in global cognition were reported in African-Americans and males after cardioembolic or large artery stroke [8]. In addition, a Montreal Cognitive Assessment (MoCA) score <26 after first-event stroke was independently associated with an increased mortality hazard ratio (7.24 [95% CI: 1.99–26.35]) [9].

Little is known concerning the effect of stroke treatment, including intravenous fibrinolysis and MT, on the incidence of poststroke dementia. Furthermore, poststroke cognitive impairment (PSCI) has no standard and clear diagnostic criteria defined as the decline of cognitive performance after a cerebrovascular event [7]. A systematic review [10] failed to draw a strong result due to the heterogeneity of endpoints measured and the small sample size of the single studies. At the same time, a positive trend was observed in some cognitive domains. More recently, Cerasuolo et al. [11], in a population-based study with 7,072 patients, demonstrated a significantly lower incidence of dementia in patients who had undergone thrombolysis compared with a control group at 5 years (35.9 [95% CI: 31.5–38.7] vs. 39.8 [95% CI: 36.8–43.0], respectively, $p = 0.048$) despite more severe stroke (NIHSS 11.33 ± 5.95 vs. 5.09 ± 5.26, respectively, $p = 0.035$). Furthermore, the prevalence of impairment of at least one cognitive domain remains significant (25%) in excellent clinical recovery (mRS ≤1) with a Mini-Mental State Examination (MMSE) score <27 of 31% [12]. The present systematic review aimed to compare the rate of PSCI in MT and control groups and the potential impact of MT on the incidence of PSCI in anterior circulation stroke.

Material and Methods

The study protocol is available upon reasonable request by mailing the corresponding author. In addition, the data used for the systematic review are publicly available. The study was drafted according to PRISMA guidelines [13].

A literature review was performed on PubMed, Ovid, and Cochrane CENTRAL for the literature from January 1, 2015 (publication of MR CLEAN trial) to the end of March 2022. The publication of the MR CLEAN trial was used as the starting point of the first successful trial on endovascularly treated stroke to ensure inclusion criteria coherence. The MeSH words used were "Stroke," "Dementia," "Thrombectomy," and "Mental Status and Dementia Tests." The search strategy was "Stroke" AND "Thrombectomy" AND "Mental Status and Dementia Tests" OR "Dementia." The inclusion criteria for studies were anterior circulation stroke patients, MT in one of the study arms, and the presence of PSCI evaluation. The exclusion criteria for the review were no-English literature and no humans. For OVID, we selected "MEDLINE® and Epub Ahead of Print, In-Process, In-Data-Review & Other Non-Indexed Citations, Daily and Versions" as databases. Initially, an automatic tool for deduplication was used in Ovid, and subsequently, Rayyan (https://www.rayyan.ai) was used for duplication screening [14]. PSCI was defined as described previously by Pendlebury et al. [7].

Furthermore, titles and abstracts were reviewed. After that, a revision of the references of the included papers was performed for papers, and a new assessment was done for potentially eligible articles for a total of 1 time (for each newly included study). Finally, the results are displayed in Figure 1. One neuro-interventional radiologist did the research with 4 years of experience.

Study Quality and Reporting Bias

The study quality was assessed using the methodological index for non-randomized studies (MINORS) criteria [15] for registries and the Risk of Bias 2 (RoB2) tool [16] for RCTs. The results are displayed in online supplementary Table S1 and S2 (for all online suppl. material, see www.karger.com/doi/10.1159/000529265). A neuro-interventional radiologist with 4 years of experience performed the evaluation. The body of evidence was evaluated with Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) [17] (online suppl. Table S3).

Data Extraction and Statistical Analysis

For each study, we collected the number of patients in both arms; stroke characteristics including age, gender, NIHSS, and Alberta Stroke Program Early CT (ASPECT) score; and all measured outcomes used for dementia (Table 1). Synthesis measures were used accordingly to normality distribution. For synthesis measures, if the median and interquartile range were used in the paper, the mean and standard deviation were estimated using quantile estimation methods [18]. Student's *t* test was used for comparing age, gender, and NIHSS among groups. R-Studio (R-project http://www.R-project.org) and OpenMeta version 12.11.14 (http://www.cebm.brown.edu/openmeta/index.html) were used as statistical software.

Despite papers included in the present systematic review evaluating different cognitive domains, a synthesis of the effect of thrombectomy on cognitive impairment can be attempted. Furthermore, as described by Pendlebury et al. [7], PSCI can be de-

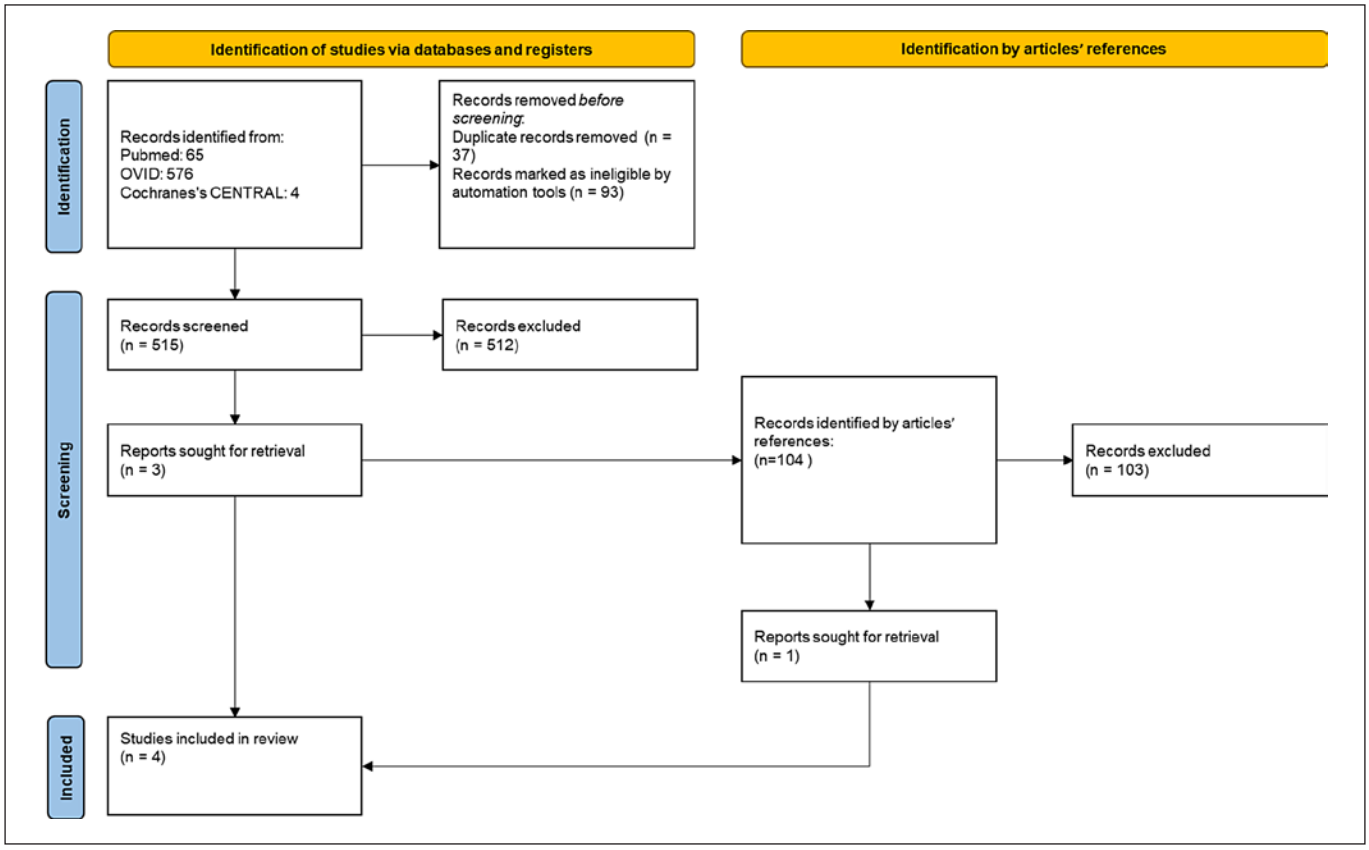


Fig. 1. Flowchart of the study.

fined as cognitive impartment after cerebrovascular disease. However, due to the lack of homogeneity among dementia tests used, standardized mean difference (Cohen's *d*) was utilized for comparing different methods used (results displayed in Table 2) [18]. In the study by Xu et al. [19], which evaluated general cognitive impairment with both MMSE and MoCA, to avoid redundancy, MoCA was selected for the analysis according to the literature [20]. On the contrary, in the remaining articles, different tests analyzed different cognitive domains; thus, all values were included in the Forest plot to avoid loss of information. Moreover, in the case of multiple follow-up times, only the last one was selected. I^2 and Cochran's Q were calculated as a measurement of homogeneity. After that, a meta-analysis was performed using the random-effect model (Fig. 2). Furthermore, Cohen's d was converted into a number needed to treat (NNT) for better clinical comprehension [21].

Results

Search and Screening Results

Six hundred forty-one studies were initially included. 130/645 (20.2%) were removed by automatic tools (Ovid deduplication system and Rayyan [https://www.rayyan.ai]). 512/515 (99.4%) studies were excluded by reviewing titles and abstracts. For each newly included article (3), an iterative references review was performed (Fig. 1). The final population encompassed four studies [19, 22–24] listed in Table 1, 3. 2/4 (50%) are sub-studies of REVASCAT trial [25]. 3/4 (75%) are randomized studies. The total number of patients was 472 (118 per study). The follow-up time ranges from 3 months to 1 year. All studies are focalized on anterior circulation. 3/4 (75%) studies compared best medical treatment (BMT) versus BMT + endovascular treatment (EVT), and 1/4 (25%) compared EVT versus BMT. No differences were found for age and sex percentage at baseline between the MT group and control group (years: 66.70 ± 11.14 vs. 67.59 ± 10.11, $p = 0.37$; male 53.8% vs. 56.4%, $p = 0.57$). The MT group had a more severe stroke than the control group (NIHSS: 14.70 ± 4.31 vs. 11.17 ± 4.12; $p < 0.0001$). The details are shown in Tables 1, 3.

Study Characteristics and Risk of Bias

There was a lack of homogeneity among cognitive tests used for dementia evaluation. Only TMT-A and TMT-B were used in 2/4 (50%) separated studies [18, 19]. The

Table 1. Clinical characteristics details

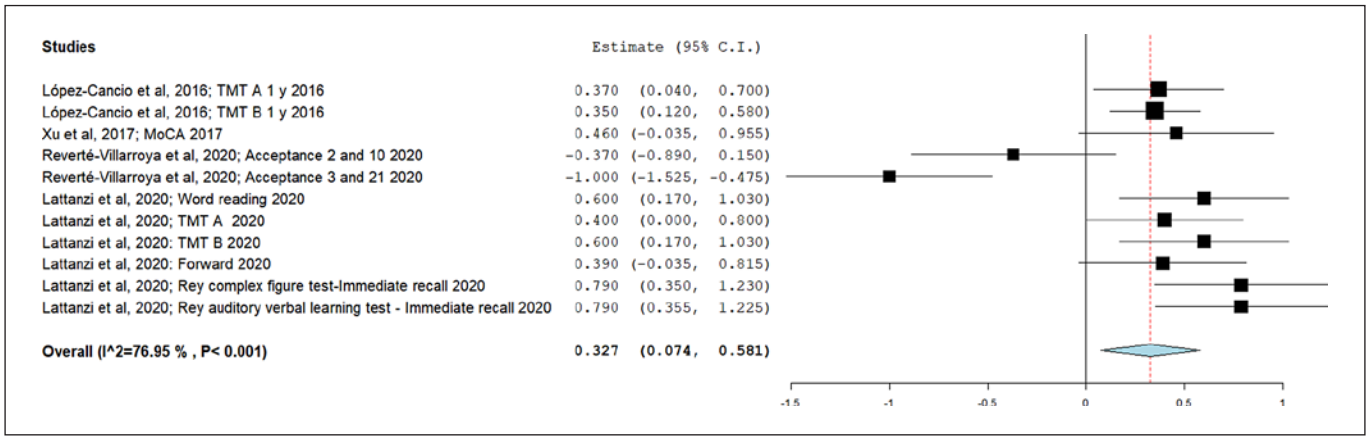
Articles	Patients, thrombectomy	Patients, control group	Age, thrombectomy (mean ± SD)	Age, control group	Male (%), thrombectomy	Male (%), control group	NIHSS, thrombectomy (mean ± SD) (median [IQR])	NIHSS, control group (mean ± SD) (median [IQR])	ASPECT, thrombectomy (median [IQR])	ASPECT, control group (median [IQR])
López-Cancio et al. [22][a]	103	103	65.7±11.3	67.2±9.5	53.4	52.4	17.0 [14.0–20.0]	17.0 [12.0–19.0]	7.0 [6.0–9.0]	8.0 [6.0–9.0]
Xu et al. [19]	67	23	69.00±8.16	68.48±8.61	52.2	52.2	10.27±1.86	10.00±1.54		
Reverté-Villarroya et al. [24]	42	40	66.76±10.15	68.47±10.72	54.8	50.0	15 [11–19]	17 [14–19]		
Lattanzi et al. [23]	50	38	65.6±14.1	67.2±11.4	56.0	76.3	15.8±4.0	10.2±5.7	8 [7–10]	9 [8–10]
Synthesis measurement	262	204	66.70±11.14	67.59±10.11	53.8	56.4	14.70±4.31	11.17±4.12		

[a]The article does not report clinical characteristics of the cohort; however, the paper is a sub-study of the REVASCAT trial so the data reported were derived from the REVASCAT trial. The sub-study was carried out in 168/171 (98.2%) patients alive at 3-month follow-up. The total population enrolled in REVASCAT was 206 patients. SD, standard deviation; NIHSS, National Institute of Health Stroke Scale, IQR, interquartile range; ASPECT, Alberta Stroke Program Early CT.

Table 2. Effect size of all tests used expressed in Cohen's *d*

Articles	Year	Patients	Comparison	Follow-up scheduled	Outcome 1, D (95% CI)	Outcome 2, D (95% CI)	Outcome 3, D (95% CI)	Outcome 4, D (95% CI)	Outcome 5, D (95% CI)
López-Cancio et al. [22]	2016	168	BMT+EVT versus BMT	3 months and 1 year	**TMT-A 3 months and 1 year** Time of completion (s) 0.22 (−0.09 to 0.52) *v* = 0.03 and 0.37 (0.04–0.70) *v* = 0.03	**TMT-B 3 months and 1 year** Time of completion (s) 0.45 (0.14–0.75) *v* = 0.03 and 0.35 (0.22–0.68) *v* = 0.03			
Xu et al. [19]	2017	96	EVT versus BMT	3 months	**MoCA** 0.46 (−0.04 to 0.95), *v* = 0.07	**MMSE** 0.59 (0.09–1.09), *v* = 0.07			
Reverté-Villarroya et al. [24]	2020	82	BMT+EVT versus BMT	3 months and 1 year	**Active coping items 2 and 10 at 1 year** −0.37 (−0.93 to 0.19) *v* = 0.08	**Acceptance items 3 and 21 at 1 year** −1 (−0.41 to −1.59) *v* = 0.09			
Lattanzi et al. [23]	2020	88	EVT+BMT versus BMT	6 months	**Stroop test** Word reading 0.6 (0.17–1.03), *v* = 0.05 Color naming 0.51 (0.09–0.95), *v* = 0.05	**TMT-A** 0.40 (0.03–0.83), *v* = 0.05 **TMT-B** 0.60 (0.17–1.03), *v* = 0.048	**Digit span test** Forward 0.39 (−0.05 to 0.80), *v* = 0.05 Backward 0.61 (0.18–1.05), *v* = 0.05 Colored progressive matrices 0.48 (0.05–0.91), *v* = 0.05	**Rey complex figure test** Copy 0.36 (−0.06 to 0.79), *v* = 0.05 Immediate recall 0.79 (0.35–1.23) *v* = 0.05 Delayed recall 0.19 (−0.24 to 0.61), *v* = 0.05	**Rey auditory verbal learning test** Immediate recall 0.79 (0.35–1.22), *v* = 0.05 Delayed recall 0.46 (0.03–0.88), *v* = 0.5

BMT, best medical therapy; EVT, endovascular thrombectomy; IQR, interquartile range; SD, standard deviation; MoCA, Montreal Cognitive Assessment; MMSE, Mini Mental State Examination; TMT, Trail Making Test; COPE-28, Coping Orientation to the Problems Experienced-28.



Color version available online

Fig. 2. Meta-analysis results and Forrest plot. Lopez-Cancio et al. [22]; Xu et al. [19]; Reverté-Villaroya et al. [24]; Lattanzi et al. [23].

other tests used were MMSE, MoCA, Coping Orientation to the Problems Experienced (COPE)-28, Stroop test, digit span test, Rey complex figure test, and Rey auditory-verbal. The risk of bias is displayed in online supplementary Table S1. The GRADE results were marked "moderate" considering RCTs and "low" including observational study (online suppl. Table S3).

Cognitive Impairment

Patients treated with EVT performed better than BMT in several cognitive domains: visual scanning and working memory (TMT-A and -B); selective attention, cognitive flexibility, processing speed (Stroop test); working memory (digit span test); visuoconstructional ability and visual memory (Rey-Osterrieth Complex Figure); immediate, delayed memory and recognition (Rey Auditory Verbal Learning Test); and overall cognition (MoCA and MMSE) (see details in Table 3). On the contrary, BMT patients scored better in COPE-28 than EVT in active coping and acceptance (Table 3).

The overall I^2 was 76.95%, and Cochran's Q was 43.40%, with a cumulative effect size of 0.33 (95% CI = 0.074–0.58) with $p < 0.001$ (Fig. 2). The NNT was 5.4; this is to say that potentially about 5 patients needed to experienced MT to obtain the clinical benefit of cognitive impairment.

Discussion

MT group patients tend to perform better at follow-up in several cognitive domains and overall cognition despite a higher NIHSS at baseline (14.70 ± 4.31 vs. 11.17 ± 4.12; $p < 0.0001$). However, there is a lack of homogeneity among studies included in the present systematic review according to the test used for cognitive impairment assessment and follow-up time, which introduces a bias in this specific analysis. The positive effect size was 0.33 (95% CI = 0.07–0.58).

Recombinant tissue plasminogen activator and MT had profound beneficial effects on mortality and disability (mRS ≤2; odds ratio: 1.17 [95% CI 1.06–1.29] and 2.49 [95% CI 1.76–3.53], respectively) [4, 26]. Although mRS is considered the standard endpoint for stroke trials [27], it is a no-domain-specific one, lacking the possibility to assess specific behaviors [28]. Using domain-specific outcomes may increase measurement resolution, helping to detect small treatment benefits [28]. Furthermore, mRS may neglect some poststroke deficits, including emotional and cognitive impairment, focusing mainly on disability [28]. However, Rudberg et al. [29] demonstrated that 14.1% of stroke survivors considered cognitive impairment the priority. One study [19] included in the present systematic review showed that in the MoCA test, patients treated with EVT scored "normal cognition" (26.23 ± 3.85) and the BMT group marked "cognitive impairment" (24.62 ± 2.2).

Moreover, Hommel et al. [30] demonstrated that stroke survivors had a lower performance in working memory compared with healthy controls (effect size: −0.65 [95% CI −0.80 to −0.51]), which is the main determinant of decreasing social function in stroke patients. Two studies demonstrated better performance in EVT patients compared with the control group in working memory, especially in time to competition (TMT-A of 3

Table 3. Results details

Articles	Year	Patients	Comparison	NIHSS	Estimated mean NIHSS	Cognitive scale	Follow-up scheduled	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5
López-Cancio et al. [22]	2016	168	BMT+EVT versus BMT	Median (IQR) 17.0 [14.0–20.0]	17±4.45	TMT-A TMT-B	3 months and 1 year	TMT-A 3 months and 1 year Completion in due time 73.2% versus 67.4% and 76.0% versus 67.4% Without errors 78.3% versus 58.6% and 81.5% versus 62.5%	TMT-B 3 months and 1 year Time of completion (s) 233.16±86.0 versus 267.76±65.8 and 225.66±89.5 versus 255.96±82.2			
Xu et al. [19]	2017	96	EVT versus BMT	Mean±SD: 10.20±1.78		MMSE MOCA	3 months	MoCA 26.23±3.85 versus 24.62±2.25; $p = 0.022$	MMSE 26.65±2.77 versus 25.10±2.36; $p = 0.023$			
Reverté-Villarroya et al. [24]	2020	82	BMT+EVT versus BMT	Median (IQR) 16 [13–19]	16±4.45	COPE-28 Items	3 months and 1 year	Active coping items 2 and 10 at 1 year: 3.63 (IQR 2.10) versus 4.74 (IQR 1.43), $p = 0.030$	Acceptance items 3 and 21 at 1 year 4.25 (IQR 1.65) versus 5.00 (IQR 1.39); $p = 0.034$			
Lattanzi et al. [23]	2020	88	EVT+BMT versus BMT	Mean±SD: 13.40±2.18		Stroop test Digit span test Rey complex figure test Rey auditory verbal TMT-A and TMT-B	6 months	**Stroop test** Word reading 41.5±11.1 versus 33.4±16.0, $p = 0.006$ Color naming 23.2±7.8 versus 18.4±10.9; $p = 0.018$	**TMT-A** 36.0 (IQR 27.0–87.0) versus 90.5 (IQR 36.0–307.0), $p = 0.005$ **TMT-B** 73.0 (IQR 41–227) versus 233.5 (IQR 57.0–562.0), $p = 0.003$	**Digit span test** Forward 5.2 (IQR 4.3–5.8) versus 4.8 (IQR 3.1–5.3), $p = 0.018$ Backward 4.1 (IQR 3.3–5.0) versus 3.2 (IQR 2.0–4.3), $p = 0.005$ Colored progressive matrices 28.8 (IQR 24.5–33.5) versus 25.0 (IQR 18.5–31.0), $p = 0.01$	**Rey complex figure test** Copy 30.5 (IQR 27.0–31.5) versus 28.0 (IQR 21.4–30.6), $p = 0.007$ Immediate recall 24.3 (IQR 18.4–28.1) versus 18.0 (IQR 12.6–24.6), $p = 0.016$ Delayed recall 18.6 (IQR 13.7–26.5) versus 16.9 (IQR 8.7–20.6), $p = 0.022$	**Rey auditory verbal learning test** Immediate recall 32.9±13.7 versus 22.9±11.3, $p < 0.001$ Delayed recall 8.6±3.0 versus 7.0±4.1, $p = 0.038$

BMT, best medical therapy; EVT, endovascular thrombectomy; IQR, interquartile range; SD, standard deviation; MoCA, Montreal Cognitive Assessment; MMSE, Mini Mental State Examination; TMT, Trail Making Test; COPE-28, Coping Orientation to the Problems Experienced-28.

months and 1 year: 73.2% vs. 67.4%; 76.0% vs. 67.4%), overall score {TMT-A: 36.0 (interquartile range [IQR] 27.0–87.0) vs. 90.5 (IQR 36.0–307.0), $p = 0.005$, and TMT-B 73.0 (IQR 41–227) vs. 233.5 (IQR 57.0–562.0), $p = 0.003$} and in forward/backward digit span test (5.2 [IQR 4.3–5.8] vs. 4.8 [IQR 3.1–5.3], $p = 0.018$; 4.1 [IQR 3.3–5.0] vs. 3.2 [IQR 2.0–4.3], $p = 0.005$, respectively) [22, 23] (Table 2).

In addition, a visuoconstructional ability detriment in stroke survival may have an important effect on daily life, including driving license release [31]. The ability to drive is a major contributor to poststroke independence [32], significantly correlated with community integration [33]. However, only 54% of stroke survivors pass the exam for license renewal [34]. Another study included in the present systematic review [23] demonstrated that EVT patients had a significantly higher score in the Rey complex figure test, which evaluates the visuoconstructional ability. Furthermore, problem-focused coping strategies improve psychological outcomes in people with chronic illnesses [35]. Interestingly, BMT patients had a better acceptance and active coping compared with EVT patients despite worst functional independency (mRS ≤2 50% vs. 27.5%, $p = 0.020$) as described by one study in this systemic review [24].

Cognitive impairment may impact patients with minor strokes who are traditionally considered to have a good recovery and are less likely to receive follow-up services [36]. These patients, by definition, have fewer disability sequelae, but a neglected cognitive deficit can have a significant impact on daily life proportionately greater than those with stroke with an NIHSS score >6 [28, 37]. Patients with "minor" stroke report alterations in executive functioning, memory, attention, and language [37], and they have a prevalence of dementia as high as 7.45% [7]. In addition, mental patient-reported outcomes are abnormal in 39.13% of patients with mRS 0–1 [38]. Furthermore, around 1/3 of patients with mRS ≤1 had a borderline MMSE [12], suggesting only a little correlation between PSCI and excellent clinical recovery. These data and observations suggest that cognitive function could be a new treatment target in minor stroke patients being NIHSS and mRS not sensitive and specific for cognitive impairment, with a great impact on their daily lives.

Despite the high/moderate degree of heterogeneity both from a clinical side (different tests for different domains) and from the statistical sides (Cochran's Q = 43.4% and $I^2 = 76.95\%$), MT demonstrated a potentially moderate/small effect on cognitive impairment (0.33 [95% CI 0.07–0.55]) [18]. This datum has to be read under the light of the prevalence of dementia in the two age-groups closer to the present systematic review mean age (65–69 years: 0.8% [0.7–0.8]; 70–74 years: 2.0 [1.9–2.0] vs. 66.70 ± 11.14 and 67.59 ± 10.11 [see Table 1]) [39]. In fact, this evidence could permit us to assume a substantial negligible prevalence of the studies' population. The NNT was 5.4, which is higher than NTT for MT in acute ischemic stroke for reducing disability at 90 days ($n = 2.6$) but similar for achieving functional independence at 90 days ($n = 5$) [4, 26]. Although the present meta-analysis had a body of evidence scored moderate to low according to GRADE systems with a high-grade inhomogeneity among studies, NNT may help in understanding the potential magnitude of the effect of MT on PSCI.

This systematic review showed high inhomogeneity among cognitive impairment tests, which reduces the readability of synthesis measurement and meta-analysis. Other authors already reported this issue [10, 37] and further suggested that it would be useful to identify shared methods to assess cognitive performance in poststroke patients. In fact, there are no standardized assessment tools for testing cognitive impairment in stroke patients [40]. Although Rost et al. [41] proposed a two-step approach with a screening test with MoCA or Oxford Cognitive Screen, only in positive patients, a more complex test battery with a 60- or 30-min protocol was performed. More efforts should be made to determine Common Data Elements for thrombectomy trials, especially for minor stroke ones.

The present study presents several limitations. First, the authors did not have access to original data at the patients' level. Second, the lack of homogeneity among studies reduced the possibility of generalizing results. Third, we mixed the general cognition test (MoCA) with specific domains due to the lack of data. However, the MoCA test involves different items exploring different cognitive domains. Furthermore, Moafmashhadi et al. [42] demonstrated a moderate correlation of MoCA with neuropsychological tests. Fourth, the meta-analysis was performed in a cohort that mixed randomized ($n = 3$) and observational ($n = 1$) studies to increase the sample size using the assumption of Shrier et al. [43].

In conclusion, PSCI seems less prevalent in thrombectomy patients than in the control group across this systematic review. However, PSCI diagnosis's inhomogeneity does not allow for synthesis measurement and meta-analysis. Therefore, further studies and RCTs are necessary to evaluate the effect of thrombectomy on cognitive impairment poststroke. Moreover, an effort to set Common Data Elements for assessing cognition in thrombectomy trials should be made.

Statement of Ethics

An ethics statement is not applicable because this study is based exclusively on published literature.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Funding Sources

The authors have no related funding sources.

Author Contributions

Conceptualization, formal analysis, and resources: Gianluca De Rubeis and Sherief Ghozy; methodology: Gianluca De Rubeis, Sherief Ghozy, Luca Saba, Giuseppe Lanzino, and David F Kallmes; software, investigation, and data curation: Gianluca De Rubeis; validation: Sebastiano Fabiano, Enrico Pampana, Luca Saba, Giuseppe Lanzino, and David F Kallmes; writing – original draft preparation: De Rubeis and Sherief Ghozy; review and editing: Sherief Ghozy, Sebastiano Fabiano, Enrico Pampana, Luca Saba, Giuseppe Lanzino, and David F Kallmes; visualization: De Rubeis and Sherief Ghozy; supervision: Sebastiano Fabiano, Enrico Pampana, Luca Saba, Giuseppe Lanzino, and David F Kallmes.

Data Availability Statement

All data generated or analyzed during this study are included in this article. Further inquiries can be directed to the corresponding author.

References

1 The top 10 causes of death; 2018.
2 Feigin VL, Stark BA, Johnson CO, Roth GA, Bisignano C, Abady GG, et al. Global, regional, and national burden of stroke and its risk factors, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet Neurol. 2021;20(10):795–820.
3 GBD 2016 Neurology Collaborators. Global, regional, and national burden of neurological disorders, 1990-2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet Neurol. 2019 May;18(5):459–80.
4 Goyal M, Menon BK, van Zwam WH, Dippel DWJ, Mitchell PJ, Demchuk AM, et al. Endovascular thrombectomy after large-vessel ischaemic stroke: a meta-analysis of individual patient data from five randomised trials. Lancet. 2016 Apr 23;387(10029):1723–31.
5 Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, et al. Guidelines for the early management of patients with acute ischemic stroke: 2019 update to the 2018 guidelines for the early management of acute ischemic stroke: a guideline for healthcare professionals from the American heart association/American stroke association. Stroke. 2019 Dec;50(12):e344–418.
6 Lyden P. Using the national institutes of health stroke scale: a cautionary tale. Stroke. 2017 Feb;48(2):513–9.
7 Pendlebury ST, Rothwell PM, Oxford Vascular Study. Incidence and prevalence of dementia associated with transient ischaemic attack and stroke: analysis of the population-based Oxford Vascular Study. Lancet Neurol. 2019;18(3):248–58.
8 Iadecola C, Duering M, Hachinski V, Joutel A, Pendlebury ST, Schneider JA, et al. Vascular cognitive impairment and Dementia: JACC scientific expert panel. J Am Coll Cardiol. 2019;73(25):3326–44.
9 Zietemann V, Georgakis MK, Dondaine T, Müller C, Mendyk A-M, Kopczak A, et al. Early MoCA predicts long-term cognitive and functional outcome and mortality after stroke. Neurology. 2018;91(20):e1838–50.
10 Broome LJ, Battle CE, Lawrence M, Evans PA, Dennis MS. Cognitive outcomes following thrombolysis in acute ischemic stroke: a systematic review. J Stroke Cerebrovasc Dis. 2016 Dec;25(12):2868–75.
11 Cerasuolo JO, Mandzia J, Cipriano LE, Kapral MK, Fang J, Hachinski V, et al. Intravenous thrombolysis after first-ever ischemic stroke and reduced incident dementia rate. Stroke. 2022 Apr;53(4):1170–7.
12 Jokinen H, Melkas S, Ylikoski R, Pohjasvaara T, Kaste M, Erkinjuntti T, et al. Post-stroke cognitive impairment is common even after successful clinical recovery. Eur J Neurol. 2015 Sep;22(9):1288–94.
13 Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71.
14 Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan: a web and mobile app for systematic reviews. Syst Rev. 2016;5(1):210.
15 Slim K, Nini E, Forestier D, Kwiatkowski F, Panis Y, Chipponi J. Methodological index for non-randomized studies (minors): development and validation of a new instrument. ANZ J Surg. 2003 Sep;73(9):712–6.
16 Sterne JAC, Savović J, Page MJ, Elbers RG, Blencowe NS, Boutron I, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ. 2019;366:l4898.
17 Guyatt G, Oxman AD, Akl EA, Kunz R, Vist G, Brozek J, et al. GRADE guidelines: 1. Introduction—GRADE evidence profiles and summary of findings tables. J Clin Epidemiol. 2011;64(4):383–94.
18 Andrade C. Mean difference, standardized mean difference (SMD), and their use in meta-analysis: as simple as it gets. J Clin Psychiatry. 2020 Sep 22;81(5):20f13681.
19 Xu G, Dong X, Niu X, Zheng G, Wang H, Zhang F, et al. Cognitive function and prognosis of multimodal neuroimage-guided thrombectomy on mild to moderate anterior circulation infarction patients with broadened therapeutic window: a prospective study. Eur Neurol. 2017;78(5–6):257–63.
20 Jia X, Wang Z, Huang F, Su C, Du W, Jiang H, et al. A comparison of the Mini-Mental State Examination (MMSE) with the Montreal Cognitive Assessment (MoCA) for mild cognitive impairment screening in Chinese middle-aged and older population: a cross-sectional study. BMC Psychiatry. 2021;21(1):485.
21 Kraemer HC, Kupfer DJ. Size of treatment effects and their importance to clinical research and practice. Biol Psychiatry. 2006;59(11):990–6.
22 López-Cancio E, Jovin TG, Cobo E, Cerdá N, Jiménez M, Gomis M, et al. Endovascular treatment improves cognition after stroke: a secondary analysis of REVASCAT trial. Neurology. 2017;88(3):245–51.

23 Lattanzi S, Coccia M, Pulcini A, Cagnetti C, Galli FL, Villani L, et al. Endovascular treatment and cognitive outcome after anterior circulation ischemic stroke. Sci Rep. 2020;10(1):18524–7.
24 Reverte-Villarroya S, Davalos A, Font-Mayolas S, Berenguer-Poblet M, Sauras-Colon E, Lopez-Pablo C, et al. Coping strategies, quality of life, and neurological outcome in patients treated with mechanical thrombectomy after an acute ischemic stroke. Int J Environ Res Public Health. 2020;17(17):6014.
25 Jovin TG, Chamorro A, Cobo E, de Miquel MA, Molina CA, Rovira A, et al. Thrombectomy within 8 hours after symptom onset in ischemic stroke. N Engl J Med. 2015;372(24):2296–306.
26 Wardlaw JM, Murray V, Berge E, del Zoppo G, Sandercock P, Lindley RL, et al. Recombinant tissue plasminogen activator for acute ischaemic stroke: an updated systematic review and meta-analysis. Lancet. 2012;379(9834):2364–72.
27 Broderick JP, Adeoye O, Elm J. Evolution of the modified rankin scale and its use in future stroke trials. Stroke. 2017;48(7):2007–12.
28 Cramer SC, Wolf SL, Saver JL, Johnston KC, Mocco J, Lansberg MG, et al. The utility of domain-specific end points in acute stroke trials. Stroke. 2021;52(3):1154–61.
29 Rudberg A-S, Berge E, Laska A-C, Jutterström S, Näsman P, Sunnerhagen KS, et al. Stroke survivors' priorities for research related to life after stroke. Top Stroke Rehabil. 2021;28(2):153–8.
30 Hommel M, Miguel ST, Naegele B, Gonnet N, Jaillard A. Cognitive determinants of social functioning after a first ever mild to moderate stroke at vocational age. J Neurol Neurosurger Psychiat. 2009;80(8):876.
31 Sundet K, Goffeng L, Hofft EVA. To drive or not to drive: neuropsychological assessment for driver's license among stroke patients. Scand J Psychol. 1995;36(1):47–58.
32 Poole D, Chaudry F, Jay WM. Stroke and driving. Top Stroke Rehabil. 2008;15(1):37–41.
33 Finestone HM, Guo M, O'Hara P, Greene-Finestone L, Marshall SC, Hunt L, et al. Driving and reintegration into the community in patients after stroke. PM R. 2010;2(6):497–503.
34 Devos H, Akinwuntan AE, Nieuwboer A, Truijen S, Tant M, De Weerdt W. Screening for fitness to drive after stroke: a systematic review and meta-analysis. Neurology. 2011;76(8):747–56.
35 Sirois FM, Molnar DS, Hirsch JK. Self-compassion, stress, and coping in the context of chronic illness. Self and Identity. 2015;14(3):334–47.
36 Terrill AL, Schwartz JK, Belagaje SR. Best practices for the interdisciplinary rehabilitation team: a review of mental health issues in mild stroke survivors. Stroke Res Treat. 2018;2018:6187328.
37 Turner GM, McMullan C, Atkins L, Foy R, Mant J, Calvert M. TIA and minor stroke: a qualitative study of long-term impact and experiences of follow-up care. BMC Fam Pract. 2019;20(1):176.
38 Cano D, Montiel E, Baladas M, Sanchez-Gavilan E, Paredes C, Rubiera M, et al. Patient-reported outcome measures after thrombectomy in patients with acute stroke: fine-tuning the modified Rankin Scale. J Neurointerv Surg. 2022:neurintsurg-2022-018840
39 Ponjoan A, Garre-Olmo J, Blanch J, Fages E, Alves-Cabratosa L, Martí-Lluch R, et al. Epidemiology of dementia: prevalence and incidence estimates using validated electronic health records from primary care. Clin Epidemiol. 2019;11:217–28.
40 Gottesman RF, Hillis AE. Predictors and assessment of cognitive dysfunction resulting from ischaemic stroke. Lancet Neurol. 2010;9(9):895–905.
41 Rost NS, Brodtmann A, Pase MP, van Veluw SJ, Biffi A, Duering M, et al. Post-stroke cognitive impairment and dementia. Circ Res. 2022;130(8):1252–71.
42 Moafmashhadi P, Koski L. Limitations for interpreting failure on individual subtests of the Montreal Cognitive Assessment. J Geriatr Psychiatry Neurol. 2013 Mar;26(1):19–28.
43 Shrier I, Boivin JF, Steele RJ, Platt RW, Furlan A, Kakuma R, et al. Should meta-analyses of interventions include observational studies in addition to randomized controlled trials? A critical examination of underlying principles. Am J Epidemiol. 2007 Nov 15;166(10):1203–9.