# Cost-Effectiveness of Endovascular Treatment in Large Vessel Occlusion Stroke With Mild Prestroke Disability

Stroke

CLINICAL AND POPULATION SCIENCES

# Cost-Effectiveness of Endovascular Treatment in Large Vessel Occlusion Stroke With Mild Prestroke Disability: Results From the HERMES Collaboration

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**BACKGROUND:** The clinical and economic benefit of endovascular treatment (EVT) in addition to best medical management in patients with stroke with mild preexisting symptoms/disability is not well studied. We aimed to investigate cost-effectiveness of EVT in patients with large vessel occlusion and mild prestroke symptoms/disability, defined as a modified Rankin Scale score of 1 or 2.

**METHODS:** Data are from the HERMES collaboration (Highly Effective Reperfusion Evaluated in Multiple Endovascular Stroke Trials), which pooled patient-level data from 7 large, randomized EVT trials. We used a decision model consisting of a short-run model to analyze costs and functional outcomes within 90 days after the index stroke and a long-run Markov state transition model (cycle length of 12 months) to estimate expected lifetime costs and outcomes from a health care and a societal perspective. Incremental cost-effectiveness ratio and net monetary benefits were calculated, and a probabilistic sensitivity analysis was performed.

**RESULTS:** EVT in addition to best medical management resulted in lifetime cost savings of $2821 (health care perspective) or $5378 (societal perspective) and an increment of 1.27 quality-adjusted life years compared with best medical management alone, indicating dominance of additional EVT as a treatment strategy. The net monetary benefits were higher for EVT in addition to best medical management compared with best medical management alone both at the higher (100 000$/quality-adjusted life years) and lower (50 000$/quality-adjusted life years) willingness to pay thresholds. Probabilistic sensitivity analysis showed decreased costs and an increase in quality-adjusted life years for additional EVT compared with best medical management only.

**CONCLUSIONS:** From a health-economic standpoint, EVT in addition to best medical management should be the preferred strategy in patients with acute ischemic stroke with large vessel occlusion and mild prestroke symptoms/disability.

**GRAPHIC ABSTRACT:** A graphic abstract is available for this article.

**Key Words:** cost savings ■ ischemic stroke ■ patients ■ quality-adjusted life year ■ thrombectomy



In 2015, 5 randomized controlled trials showed the benefit of endovascular treatment (EVT) compared to best medical management in acute ischemic stroke due to large vessel occlusion (LVO).[1] Patients with prestroke disability, which is most often defined as a modified Rankin Scale (mRS) score of ≥ 2, were, however, largely excluded from these trials for pragmatic reasons, that is, to maximize the probability of detecting

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## Nonstandard Abbreviations and Acronyms

| | |
|---|---|
| **EVT** | endovascular treatment |
| **LVO** | large vessel occlusion |
| **mRS** | modified Rankin Scale |
| **NMB** | net monetary benefit |
| **QALY** | quality-adjusted life year |

a significant treatment effect and to allow for utilization of dichotomized outcomes, such as good outcome (eg, mRS score of 0–2). As a result, there is paucity of randomized data regarding the clinical and economic benefit of EVT in patients with prestroke disability, resulting in a lack of clear guideline recommendations. The current American Heart Association/American Stroke Association guidelines state that "patients should receive mechanical thrombectomy if they have a prestroke mRS of 0 or 1."[2] For patients with mRS score >1, which account for more than one-third of all acute ischemic stroke cases,[3,4] there are no clear guideline-based EVT recommendations, and physicians have to rely mostly on their own judgment. This increases the risk for personal biases in clinical decision-making, may lead to substantial variability in treatment practices, and ultimately compromise the quality of care.[5] The potential for cost savings in patients with prestroke symptoms/disability is likely to be greater compared to patients without prestroke symptoms/disability since they will generally experience outcomes at the higher end of the mRS spectrum, at which treatment costs disproportionately increase. Achieving a shift from a poststroke mRS score of 4 to 3 through EVT, for example, may result in greater cost savings compared to a shift from poststroke mRS score of 2 to 1.

So far, hardly any patients with severe preexisting symptoms/disability (mRS score >2) were included in any of the EVT trials, and thus, no reliable conclusions can be drawn regarding the health-economic impact of EVT in this patient subgroup. However, the HERMES collaboration (Highly Effective Reperfusion Evaluated in Multiple Endovascular Stroke Trials) did include 199 patients with mild preexisting symptoms/disability (prestroke mRS score 1–2). Our group has previously conducted EVT cost-effectiveness analyses in much smaller samples.[6] Based on our previous experience, we, therefore, expected 199 patients to be a sufficiently large sample for assessing cost-effectiveness.

Thus, we used data from the HERMES collaboration to compare the long-term costs and cost-effectiveness of EVT in addition to best medical management to best medical management alone in patients with acute ischemic stroke with LVO and mild prestroke symptoms/disability, defined as mRS score of 1 or 2 before stroke onset.

# METHODS

The individual studies pooled in the HERMES meta-analysis were approved by the institutions' local ethics committees and patients were enrolled based on informed consent unless deferral of consent was used according to local regulations. The raw data underlying this analysis will be made available by the corresponding author and after approval by the HERMES executive committee upon reasonable request. We conducted this analysis in accordance with the recommendations of the Second Panel on Cost-Effectiveness in Health and Medicine[7] and the Consolidated Health Economic Evaluation Reporting Standards 2022 guidelines[8] (see checklist in the Supplemental Material). Analyses were conducted both from a health care perspective and a societal perspective. This was a post hoc economic analysis of a large existing dataset, and as such, we did not develop an a priori health economic analysis plan.

## Study Sample

The HERMES collaboration pooled patient data from 7 randomized controlled trials that investigated safety and efficacy of EVT in patients with acute ischemic stroke (n=1766).[1,9–15] Patients were enrolled between December 2010, and December 2014. Inclusion criteria of the individual trials have been previously published.[9–15] Patients who were randomized to the control arms of the respective trials were treated with best medical management, including intravenous alteplase if indicated. Those randomized to the EVT arms were treated with EVT in addition to best medical management. HERMES included 199 patients with prestroke mRS score 1 or 2; 98 in the EVT arm and 101 in the best medical management arm.[16]

## Model Structure

A decision model was developed using the TreeAge pro-2021 software, version 21.1.1 (TreeAge, Williamstown, MA; Figure 1). First, a short-run model was used to analyze costs and outcomes within the first 3 months after the index stroke, followed by a long-run Markov state transition state model with a cycle length of 12 months, estimating costs and outcomes over the patients' lifespan up to 120 years. In the short-run model, patients could enter 1 of 7 health states as defined by the mRS following treatment (ie, EVT and best medical management in the EVT arm; best medical management alone in the control arm). In each cycle of the long-run model, patients could maintain the same health status (ie, the same mRS category), suffer a recurrent stroke followed by either recovery to the same mRS category or change to a worse mRS category, or die, either as a result of age-related mortality or stroke-survivor specific mortality. In the base case analysis of this study, we assumed a patient age at stroke onset of 71.5 years, as this was the median age of patients with prestroke mRS score 1 to 2 in HERMES.

## Model Parameters

1. Outcome probabilities. The probabilities of achieving a certain mRS state at 3 months in the short-run model were derived from the HERMES collaboration.[16]

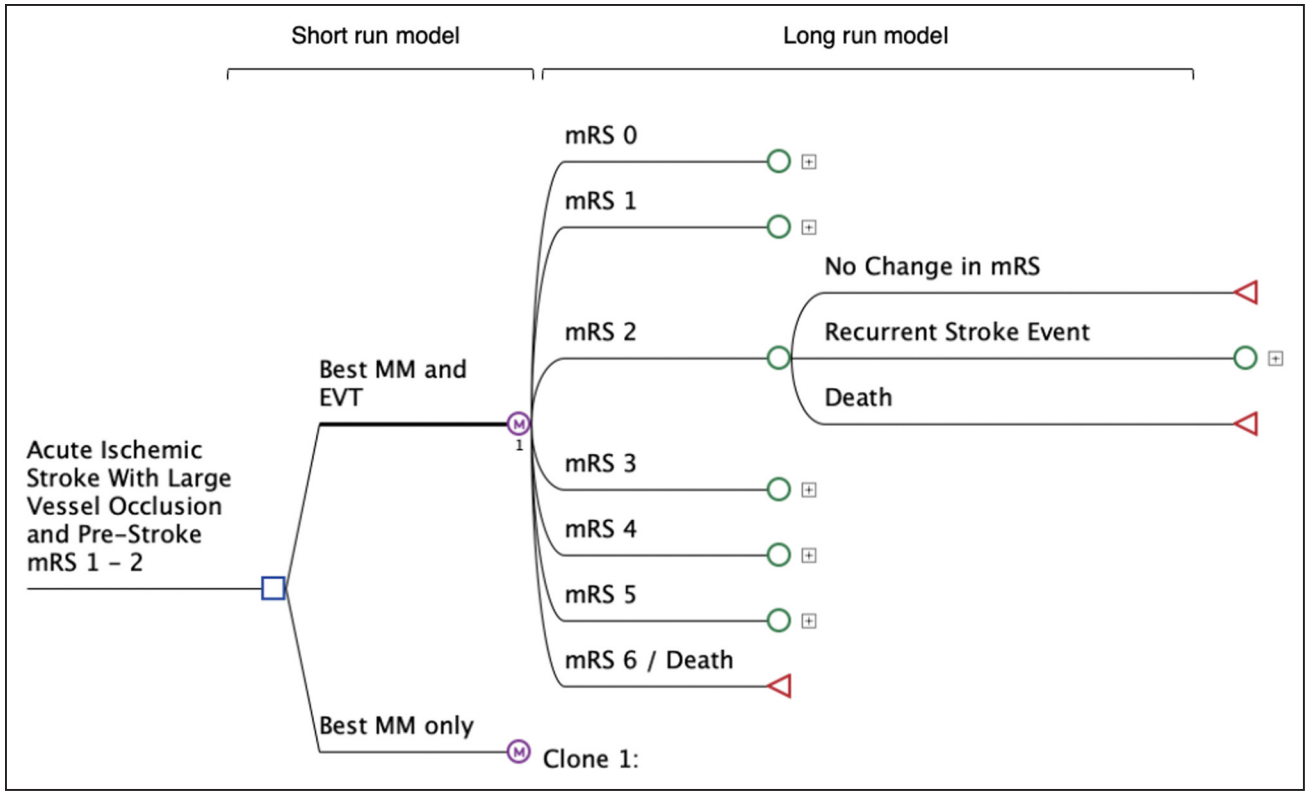


**Figure 1. Decision model used in this study.**
The decision model consists of a short-run model and a long-run Markov transition state model. The short-run model is used to estimate costs within the first 3 mo after the index stroke. The long-run Markov model is used to estimate transitions between states and costs after the first 3 mo after the index stroke. Note that best medical management (MM) also includes intravenous thrombolysis if indicated. A square indicates a decision node, in this case the decision to treat either with endovascular treatment (EVT) and best MM or with best MM alone. Circles indicate chance nodes. Circles with the letter M indicate Markov nodes. Triangles indicate terminal nodes. Clone 1 indicates a subtree for the best MM-only arm with a structure that is identical to the tree shown in the EVT in addition to best MM arm. mRS indicates modified Rankin Scale.

Probabilities for long-term outcomes beyond 3 months were extracted from large prospective cohort studies[17,18] and United States Life Tables,[19] as described previously,[6,20] taking into account the risk of recurrent stroke, death, and changes in mRS over time in poststroke survivors. mRS-specific utility measures were derived from a large prospective cohort study.[21] Other parameters that were used in the model have been published previously.[6,20]

2. Health care Costs (US data). Estimated treatment costs were derived from the National Inpatient Sample[22] and available literature, as described previously.[6,20,23] The cost of EVT over and above best medical management was estimated to be $15 510, which includes all devices and other procedure-related materials.[23] Costs of best medical management include the cost of intravenous alteplase if indicated, which was estimated using US pricing at $7421. Intravenous alteplase and EVT were hereby accounted for separately from the acute care component in the model, following the methodology of previous papers.[6,24,25] To account for the fact that not all patients with mild prestroke disability received intravenous alteplase as part of best medical management, the cost of intravenous alteplase was multiplied by the probability of patient with prestroke mRS score of 1 to 2 in the HERMES collaboration receiving intravenous alteplase (75.5% in the EVT arm and 81.2% in the control arm; modeled with a beta-distribution and assuming a SD of 20%).[16] Health care costs other than procedure-related costs that were considered in the first 3 months (short-run model) included supported discharge, rehabilitation, and community care, according to the degree of disability as measured by the mRS at 3 months.[26] Long-term costs beyond 3 months from the index stroke included rehabilitation and ongoing costs, according to the degree of disability as measured by the mRS at 3 months.[23] All costs were inflated by medical care component of the consumer price index.[27] If only foreign currency values were available, the exchange rate from the year of data origin to USD was used and subsequently adjusted to US inflation, identical to the costs that were available from the literature in US currency.
3. Societal Costs. Costs and cost-effectiveness of EVT in addition to best medical management compared to best medical management alone were assessed using the human capital approach, including costs caused by lost productivity and informal care (estimated based on United States Census Bureau wages[28] and United States Bureau of Labor Statistics[27] age-specific employment rates[6,20]),

costs of informal care 6 and costs of lost productivity due to stroke-related premature mortality and disability, as described previously.[6] Details of the model parameters and respective references are shown in Table 1.

## Outcomes

Cost-effectiveness of EVT in addition to best medical management was assessed with the incremental cost-effectiveness ratio, which reflects the difference in costs between EVT with best medical management and best medical management alone and the respective gain in quality-adjusted life years (QALYs).

$$\frac{(\text{Average cost of EVT best MM}) - \text{Average cost of best MM}}{(\text{Average cost of EVT best MM}) - \text{Average QALYs of best MM}} = \frac{\text{Average additional cost of EVT}}{\text{Average gain in QALYs with EVT}}$$

QALYs reflect both survival time and quality of life: one year of life in a completely healthy state results in 1 QALY, and one year of life with any health-related impairment results in <1 QALY, depending on the nature and degree of impairment.[34] QALYs for each mRS category were calculated using utility values associated with each mRS state. All QALYs were discounted by 3% each year.[7] The net monetary benefit (NMB) of EVT with best medical management and best medical management alone was calculated. The NMB equals the mean QALYs per patient gained with EVT multiplied by the willingness to pay for one QALY minus the mean additional cost of EVT (compared to best medical management) per patient. According to common convention, upper and lower willingness to pay thresholds were set at $100 000 and $50 000.

$$\text{NMB} = (\text{lifetime QALYs gained with EVT} \times \text{willingness to pay for 1 QALY}) - \text{lifetime additional costs of EVT}$$

## Sensitivity Analysis

Every parameter used in the decision model was assigned a distribution type reflecting its probability density function. We then performed probabilistic sensitivity analysis using 10 000 second-order Monte Carlo simulation runs to assess for the influence of simultaneous changes in model input parameters. Median costs, QALYs, and NMB for both EVT with best medical management and best medical management alone were obtained from the 10 000 simulations and graphed in a scatter plot.

# RESULTS

Of the 199 HERMES patients with prestroke mRS score 1 or 2, 48 (24.1%) achieved a good outcome at 90 days (mRS score 0–2) and 56 (28.1%) died. In the EVT arm, 74 out of 98 (75.5%) patients received IV alteplase in

**Table 1. Base Case Values and Model Input Parameters**

| Parameter | Expected value | Distribution | References |
|---|---|---|---|
| Initial probabilities for achieving mRS score 0/1/2/3/4/5/6 | | | |
| EVT arm | 6/11/15/16/19/7/24 | Dirichlet | McDonough et al[16] |
| Control arm | 1/8/7/15/22/16/32 | | |
| Transition probabilities | | | |
| Recurrent stroke rate | 0.074 (for first year) | Beta | Pennlert et al[18] |
| Annual death rate | 0.013 (for 65 years) | Beta | Arias et al[19] |
| Annual death hazard rate ratios for mRS score 0/1/2/3/4/5 | 1.53/1.52/2.17/3.18/4.55/6.55 | Log-normal | Hong et al[17] |
| After recurrent stroke | HERMES meta-analysis control arm | Dirichlet | Goyal et al[1] |
| Health care costs | | | |
| Costs within first 90 days after stroke for mRS score 0/1/2/3/4/5/6 | $7515/$10 375/$16 294/$20 151/$27 002/$32 256/$7421 | Gamma | Dawson et al[26] |
| Additional cost of IV thrombolysis | $7421 | Gamma | National Inpatient Sample 2014[29] |
| Additional cost of EVT | $15 510 | Gamma | Shireman et al[23] |
| Long-term annual costs after stroke for mRS score 0/1/2/3/4/5 | $10 569/$10 883/$12 590/$21 618/$43 755/$64 327 | Gamma | Shireman et al[23] |
| Costs for hospitalization due to recurrent stroke | $21 648 | Gamma | Chambers et al[30] |
| Societal costs | | | |
| Average annual earnings of employed population | $33 000 (for 65 years) | Gamma | US Census Bureau 2017 |
| Population employment rate | 0.312 (for 65 years) | Beta | US Bureau of Labor Statistics 2017[27] |
| Relative earnings of stroke survivors | 0.825 | Beta | Vyas et al[31] |
| Return to work probability after stroke for mRS score 0/1/2/3/4/5 | 0.63/0.72/0.49/0.19/0.14/0.00 | Beta | Tanaka et al[32] |
| Informal annual caregiving costs | mRS score 0–1: $1413, mRS score 2–5: $7066 | Gamma | Hickenbottom et al[33] |
| Utilities mRS score 0/1/2/3/4/5/6 | 1.00/0.91/0.76/0.65/0.33/0.00/0.00 | Beta | Chaisinanunkul et al[21] |

EVT indicates endovascular treatment; HERMES, Highly Effective Reperfusion Evaluated in Multiple Endovascular Stroke Trials; and mRS, modified Rankin Scale.

addition to EVT, and in the control arm, 82 out of 101 (81.2%) received IV alteplase. Clinical outcomes with EVT and best medical management showed a clear benefit of EVT (32% good outcome [mRS score 0–2] in the EVT arm versus 16% in the control arm, adjusted common odds ratio for a shift on the mRS score of 2.08 [95% CI, 1.22–3.55]), and are reported in detail elsewhere.[16]

## Base Case Analysis

From a health care perspective, EVT in addition to best medical management resulted in lifetime cost savings of $2821 and an increment of 1.27 QALYs, suggesting that EVT in addition to best medical management is the dominant treatment strategy in patients with mild prestroke symptoms/disability. Accordingly, EVT in addition to best medical management yielded a higher NMB compared to best medical management alone at the higher (EVT, $153 671 versus best medical management only, $23 850) and lower (EVT, −$31 329 versus best medical management only, −$97 650) willingness to pay thresholds.

Results were similar in the analysis from a societal perspective. EVT in addition to best medical management resulted in lifetime cost savings of $5378 and an increment of 1.27 QALYs, again suggesting dominance of EVT in addition to best medical management as a treatment strategy. EVT in addition to best medical management also yielded a higher NMB compared to best medical management alone at the higher (EVT: $107 544 versus best medical management only: −$24 834) and lower (EVT: −$77 456 versus best medical management only: −$146 334) willingness to pay thresholds (Table 2).

## Sensitivity Analysis

Figure 2 shows the results of the probabilistic sensitivity analysis (10 000 simulations). The majority of simulations resulted in decreased costs and a gain in QALYs with EVT in addition to best medical management compared to best medical management only.

**Table 2. Costs and QALYs Gained With EVT in Addition to Best Medical Management and Best Medical Management Only in Patients With Mild Prestroke Symptoms/Disability**

| | EVT with best medical management | Best medical management only | Difference |
|---|---|---|---|
| Cumulative lifetime QALYs gained | 3.70 | 2.43 | 1.27 |
| Health care perspective | | | |
| Cumulative lifetime costs, $ | 216 329 | 219 150 | −2821 |
| Societal perspective | | | |
| Cumulative lifetime costs, $ | 262 456 | 267 834 | −5378 |

Note that best medical management includes intravenous alteplase, if indicated. EVT indicates endovascular treatment; and QALY, quality-adjusted life years.

## DISCUSSION

In this cost-effectiveness study, EVT in addition to best medical management for LVO stroke with mild preexisting symptoms/disability is associated with a gain in QALYs as well as a decrease in lifetime costs compared to best medical management alone.

There is substantial uncertainty on whether EVT should be performed in patients with preexisting symptoms/disability, and treatment practices are highly variable.[35] The most commonly used argument against treating these patients with EVT is that functional outcomes are often poor, especially when compared to patients without preexisting symptoms/disability.[36,37] Indeed, a post hoc analysis of the HERMES collaboration showed that clinical outcome at 3 months is worse in patients with mild preexisting disability (mRS score 1–2), but this held true both for the control and EVT arms.[16] Furthermore, there was no evidence of treatment effect modification of EVT by prestroke mRS, suggesting that the effect of EVT is similar in patients with and without mild preexisting symptoms/disability. Although the former may be at a slightly higher risk of death compared with the latter, they are not more likely to accumulate additional disability over and beyond their preexisting deficits compared to those patients without preexisting symptoms/disability.[38]

Nevertheless, EVT decision-making in prestroke symptomatic/disabled patients is complicated. Physicians tend to focus their treatment decisions around a patient's overall prognosis, rather than treatment effect, and rightly so, because the prognosis is ultimately what matters to the patients themselves. However, they often underestimate the quality of life of prestroke symptomatic/disabled patients, which can result not only in undertreatment with EVT but also in withdrawal or foregoing of other supportive treatments, even if EVT is performed. This in turn may lead to worse outcomes, resulting in a vicious circle and a "self-fulfilling prophecy."[5,39] An open communication with the patients and families about their expectations and desirable outcomes can help to avoid these biases and make treatment decisions in line with individual patients' wishes.

Additional, complementary outcome measures such as mortality and cost-effectiveness can also aid in the decision-making process, by providing supplementary information that is not subject to personal biases and judgments. The current study shows that EVT is the preferred strategy from a health economics standpoint in patients with mild prestroke symptoms/disability. The increment in QALYs with EVT was hereby slightly lower compared to the overall HERMES patient sample (1.27 in the current study versus 1.59 in the overall HERMES



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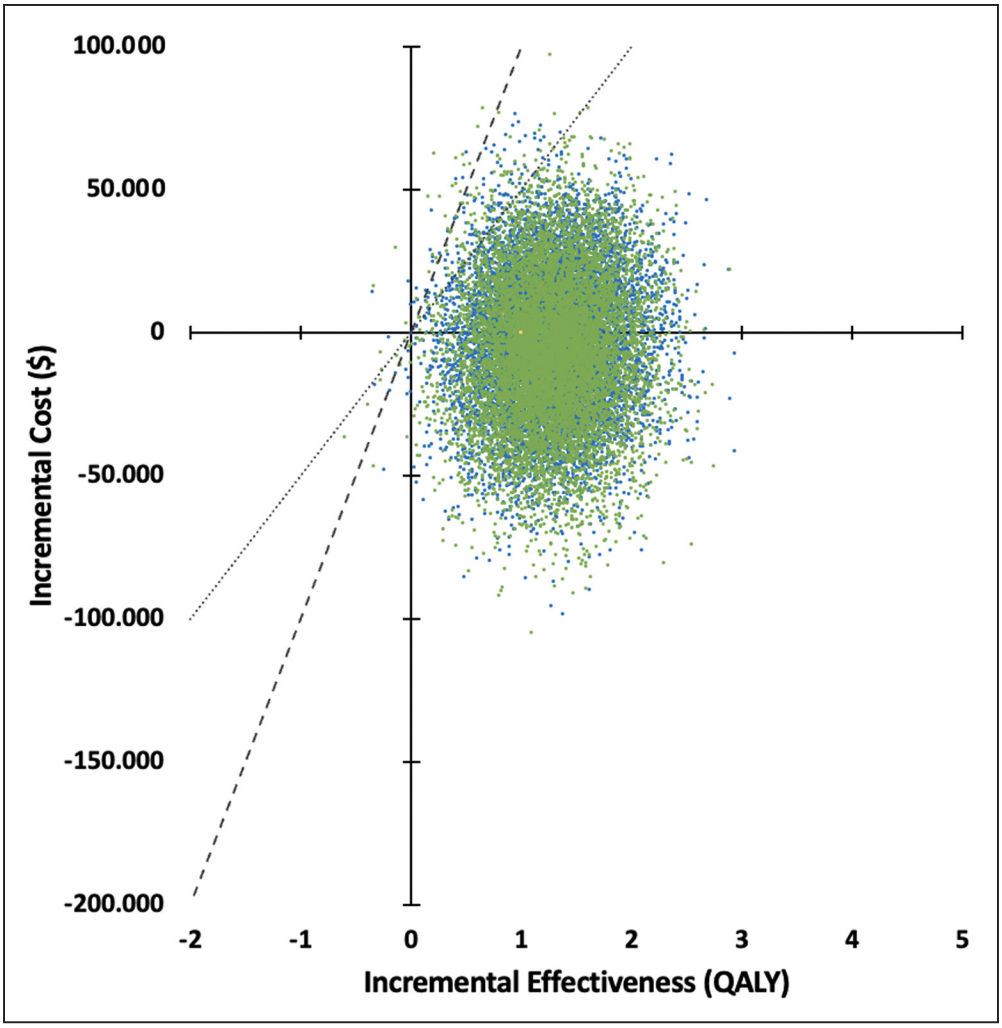


**Figure 2. Results of the probabilistic sensitivity analysis (10 000 simulations) showing incremental cost per quality-adjusted life year (QALY) gained of endovascular treatment in addition to best medical management from a societal perspective (green dots, online only) and health care perspective (blue dots, online only) in patients with mild prestroke symptoms/disability.** The majority of simulation results are in the lower right quadrant, that is, costs are decreased and QALYs are increased. Almost all results are below the 50 000/QALY willingness to pay threshold (dotted line) as well as the 100 000/QALY willingness to pay threshold (dashed line), indicating a high probability that EVT in addition to best medical management is cost-effective compared to best medical management alone.

sample[25]). Nevertheless, health economics data clearly suggest benefit of EVT, providing support to the argument that EVT should be routinely considered in patients with mild prestroke symptoms/disability.[40,41] Ideally, guidelines should acknowledge this to allow for broader adoption of EVT in patients with prestroke symptoms/disability.

In the long term, it would be desirable to design more inclusive randomized trials and prospective cohort studies that do not systematically exclude patients with preexisting symptoms/disability, an approach that has already been adopted in some more recent EVT trials. This allows us not only to collect more and better data but also avoids systematic exclusion of certain patient subgroups, for example, women since they are on average older and more often symptomatic/disabled before stroke onset.[42] Of note, because of the stringent inclusion criteria of the HERMES trials, we were not able to investigate outcomes in patients with prestroke mRS score >2. We suspect that the relative treatment benefit of EVT would be maintained in those patients as well, but this is purely speculative at this point and should be confirmed in prospective studies.

## Limitations

Our study has several limitations. First, available data on clinical outcomes of patients with LVO stroke with prestroke symptoms/disability are limited, particularly for patients with severe prestroke symptoms/disability. We, therefore, had to limit our analysis to patients with mild preexisting symptoms/disability, and the sample size on which our outcome estimation was based was relatively small. Moreover, because of a potential selection bias due to rather stringent randomized trial enrollment criteria, these patients may also not be representative of the general population of LVO patients with mild prestroke

symptoms/disability. Second, treatment costs, particularly the cost of EVT and intravenous alteplase, and societal costs differ among countries. This analysis was conducted using mostly US data and, as such, the results may not be generalizable to other countries. Lastly, accurate assessment of prestroke mRS is challenging in the acute setting, and acute prestroke mRS is misjudged by at least one category in up to 30% of patients,[43] which may have introduced some variability in this study.

## Conclusions

EVT in addition to best medical management led to lower estimated lifetime costs and a gain in QALYs compared to best medical management alone in patients with LVO stroke with mild preexisting symptoms/disability. From a health economics perspective, EVT in addition to best medical management is, therefore, the preferred strategy for this patient subgroup.

## ARTICLE INFORMATION

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## REFERENCES

1. Goyal M, Menon BK, van Zwam WH, Dippel DW, Mitchell PJ, Demchuk AM, Davalos A, Majoie CB, van der Lugt A, de Miquel MA, et al. Endovascular thrombectomy after large-vessel ischaemic stroke: a meta-analysis of individual patient data from five randomised trials. *Lancet*. 2016;387:1723–1731. doi: 10.1016/S0140-6736(16)00163-X
2. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, Biller J, Brown M, Demaerschalk BM, Hoh B, 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;50:e344–e418. doi: 10.1161/STR.0000000000000211
3. Ganesh A, Luengo-Fernandez R, Pendlebury ST, Rothwell PM. Long-term consequences of worsened poststroke status in patients with premorbid disability. *Stroke*. 2018;49:2430–2436. doi: 10.1161/STROKEAHA.118.022416
4. Krahn GL, Walker DK, Correa-De-Araujo R. Persons with disabilities as an unrecognized health disparity population. *Am J Public Health*. 2015;105:S198–S206. doi: 10.2105/AJPH.2014.302182
5. Young MJ, Regenhardt RW, Leslie-Mazwi TM, Stein MA. Disabling stroke in persons already with a disability: ethical dimensions and directives. *Neurology*. 2020;94:306–310. doi: 10.1212/WNL.0000000000008964
6. Sarraj A, Pizzo E, Lobotesis K, Grotta JC, Hassan AE, Abraham MG, Blackburn S, Day AL, Dannenbaum MJ, Hicks W, SELECT Investigators, et al. Endovascular thrombectomy in patients with large core ischemic stroke: a cost-effectiveness analysis from the SELECT study. *J Neurointerv Surg*. 2021;13:875–882. doi: 10.1136/neurintsurg-2020-016766
7. Sanders GD, Neumann PJ, Basu A, Brock DW, Feeny D, Krahn M, Kuntz KM, Meltzer DO, Owens DK, Prosser LA, et al. Recommendations for conduct, methodological practices, and reporting of cost-effectiveness analyses: second panel on cost-effectiveness in health and medicine. *JAMA*. 2016;316:1093–1103. doi: 10.1001/jama.2016.12195
8. Husereau D, Drummond M, Augustovski F, de Bekker-Grob E, Briggs AH, Carswell C, Caulley L, Chaiyakunapruk N, Greenberg D, Loder E, et al. Consolidated health economic evaluation reporting standards 2022 (CHEERS 2022) statement: updated reporting guidance for health economic evaluations. *BMJ*. 2022;376:e067975. doi: 10.1136/bmj-2021-067975
9. Berkhemer OA, Fransen PS, Beumer D, van den Berg LA, Lingsma HF, Yoo AJ, Schonewille WJ, Vos JA, Nederkoorn PJ, Wermer MJ, et al; MR CLEAN Investigators. A randomized trial of intraarterial treatment for acute ischemic stroke. *N Engl J Med*. 2015;372:11–20. doi: 10.1056/NEJMoa1411587
10. Bracard S, Ducrocq X, Mas JL, Soudant M, Oppenheim C, Moulin T, Guillemin F, investigators T. Mechanical thrombectomy after intravenous alteplase versus alteplase alone after stroke (THRACE): a randomised controlled trial. *Lancet Neurol*. 2016;15:1138–1147. doi: 10.1016/S1474-4422(16)30177-6
11. Campbell BC, Mitchell PJ, Kleinig TJ, Dewey HM, Churilov L, Yassi N, Yan B, Dowling RJ, Parsons MW, Oxley TJ, et al; EXTEND-IA Investigators. Endovascular therapy for ischemic stroke with perfusion-imaging selection. *N Engl J Med*. 2015;372:1009–1018. doi: 10.1056/NEJMoa1414792
12. Goyal M, Demchuk AM, Menon BK, Eesa M, Rempel JL, Thornton J, Roy D, Jovin TG, Willinsky RA, Sapkota BL, et al; ESCAPE Trial Investigators. Randomized assessment of rapid endovascular treatment of ischemic stroke. *N Engl J Med*. 2015;372:1019–1030. doi: 10.1056/NEJMoa1414905
13. Jovin TG, Chamorro A, Cobo E, de Miquel MA, Molina CA, Rovira A, San Roman L, Serena J, Abilleira S, Ribo M, et al; REVASCAT Trial Investigators. Thrombectomy within 8 hours after symptom onset in ischemic stroke. *N Engl J Med*. 2015;372:2296–2306. doi: 10.1056/NEJMoa1503780
14. Muir KW, Ford GA, Messow CM, Ford I, Murray A, Clifton A, Brown MM, Madigan J, Lenthall R, Robertson F, et al; PISTE Investigators. Endovascular therapy for acute ischaemic stroke: the Pragmatic Ischaemic Stroke Thrombectomy Evaluation (PISTE) randomised, controlled trial. *J Neurol Neurosurg Psychiatry*. 2017;88:38–44. doi: 10.1136/jnnp-2016-314117
15. Saver JL, Goyal M, Bonafe A, Diener HC, Levy EI, Pereira VM, Albers GW, Cognard C, Cohen DJ, Hacke W, et al; SWIFT PRIME Investigators. Stent-retriever thrombectomy after intravenous t-PA vs. t-PA alone in stroke. *N Engl J Med*. 2015;372:2285–2295. doi: 10.1056/NEJMoa1415061

16. McDonough RV, Ospel JM, Majoie CBLM, Saver JL, White P, Dippel DWJ, Brown SB, Demchuk AM, Jovin TG, Mitchell PJ, HERMES collaborators, et al. Clinical outcome of patients with mild pre-stroke morbidity following endovascular treatment: a HERMES substudy [published online February 24, 2022]. *J NeuroInterv Surg*. 2022. doi: 10.1136/neurintsurg-2021-018428
17. Hong KS, Saver JL. Years of disability-adjusted life gained as a result of thrombolytic therapy for acute ischemic stroke. *Stroke*. 2010;41:471–477. doi: 10.1161/STROKEAHA.109.571083
18. Pennlert J, Eriksson M, Carlberg B, Wiklund PG. Long-term risk and predictors of recurrent stroke beyond the acute phase. *Stroke*. 2014;45:1839–1841. doi: 10.1161/STROKEAHA.114.005060
19. Arias E, Heron M, Xu J. United States life tables, 2014. *Natl Vital Stat Rep*. 2017;66:1–64.
20. Kunz WG, Hunink MG, Dimitriadis K, Huber T, Dorn F, Meinel FG, Sabel BO, Othman AE, Reiser MF, Ertl-Wagner B, et al. Cost-effectiveness of endovascular therapy for acute ischemic stroke: a systematic review of the impact of patient age. *Radiology*. 2018;288:518–526. doi: 10.1148/radiol.2018172886
21. Chaisinanunkul N, Adeoye O, Lewis RJ, Grotta JC, Broderick J, Jovin TG, Nogueira RG, Elm JJ, Graves T, Berry S, et al; DAWN Trial and MOST Trial Steering Committees. Adopting a patient-centered approach to primary outcome analysis of acute stroke trials using a utility-weighted modified rankin scale. *Stroke*. 2015;46:2238–2243. doi: 10.1161/STROKEAHA.114.008547
22. AHRQ. HCUPnet: a tool for identifying, tracking, and analyzing national hospital statistics. https://hcupnet.ahrq.gov/#setup. Accessed July 24.
23. Shireman TI, Wang K, Saver JL, Goyal M, Bonafe A, Diener HC, Levy EI, Pereira VM, Albers GW, Cognard C, et al; SWIFT-PRIME Investigators. Cost-effectiveness of solitaire stent retriever thrombectomy for acute ischemic stroke: results from the SWIFT-PRIME trial (Solitaire With the Intention for Thrombectomy as Primary Endovascular Treatment for Acute Ischemic Stroke). *Stroke*. 2017;48:379–387. doi: 10.1161/STROKEAHA.116.014735
24. Kunz WG, Almekhlafi MA, Menon BK, Saver JL, Hunink MG, Dippel DWJ, Majoie C, Liebeskind DS, Jovin TG, Davalos A, et al. Public health and cost benefits of successful reperfusion after thrombectomy for stroke. *Stroke*. 2020;51:899–907. doi: 10.1161/STROKEAHA.119.027874
25. Kunz WG, Hunink MG, Sommer WH, Beyer SE, Meinel FG, Dorn F, Wirth S, Reiser MF, Ertl-Wagner B, Thierfelder KM. Cost-effectiveness of endovascular stroke therapy: a patient subgroup analysis from a US healthcare perspective. *Stroke*. 2016;47:2797–2804. doi: 10.1161/STROKEAHA.116.014147
26. Dawson J, Lees JS, Chang TP, Walters MR, Ali M, Davis SM, Diener HC, Lees KR, GAIN and VISTA Investigators. Association between disability measures and healthcare costs after initial treatment for acute stroke. *Stroke*. 2007;38:1893–1898. doi: 10.1161/STROKEAHA.106.472381
27. BLS. US Bureau of Labor Statistics: consumer Price Index (CPI). https://www.bls.gov/cpi/. Accessed July 24.
28. CPS. U.S. Census Bureau. Current Population Survey (CPS) - CPS table creator. Accessed July 24, 2022. https://www.census.gov/topics/income-poverty/income/data/tables.html.
29. AHRQ. Agency for Healthcare Research and Quality(AHRQ): HCUPnet - A tool for identifying, tracking and analzying national hospital statistics. https://hcupnet.ahrq.gov/#setup. 2021. Accessed April 30.
30. Chambers MG, Koch P, Hutton J. Development of a decision-analytic model of stroke care in the United States and Europe. *Value Health*. 2002;5:82–97. doi: 10.1046/j.1524-4733.2002.52011.x
31. Vyas MV, Hackam DG, Silver FL, Laporte A, Kapral MK. Lost productivity in stroke survivors: an econometrics analysis. *Neuroepidemiology*. 2016;47:164–170. doi: 10.1159/000454730
32. Tanaka H, Toyonaga T, Hashimoto H. Functional and occupational characteristics predictive of a return to work within 18 months after stroke in Japan: implications for rehabilitation. *Int Arch Occup Environ Health*. 2014;87:445–453. doi: 10.1007/s00420-013-0883-8
33. Hickenbottom SL, Fendrick AM, Kutcher JS, Kabeto MU, Katz SJ, Langa KM. A national study of the quantity and cost of informal caregiving for the elderly with stroke. *Neurology*. 2002;58:1754–1759. doi: 10.1212/wnl.58.12.1754
34. Prieto L, Sacristan JA. Problems and solutions in calculating quality-adjusted life years (QALYs). *Health Qual Life Outcomes* 2003;1:80. doi: 10.1186/1477-7525-1-80
35. Salwi S, Niec JA, Hassan AE, Lindsell CJ, Khatri P, Mocco J, Saver JL, Mistry EA. Endovascular Treatment for Acute Stroke Patients With a Prestroke Disability: An International Survey. *Front Neurol*. 2021;12:714594. doi: 10.3389/fneur.2021.714594
36. Leker RR, Gavriliuc P, Yaghmour NE, Gomori JM, Cohen JE. Increased Risk for Unfavorable Outcome in Patients with Pre-Existing Disability Undergoing Endovascular Therapy. *J Stroke Cerebrovasc Dis*. 2018;27:92–96. doi: 10.1016/j.jstrokecerebrovasdis.2017.08.007
37. Salwi S, Cutting S, Salgado AD, Espaillat K, Fusco MR, Froehler MT, Chitale RV, Kirshner H, Schrag M, Jasne A, et al. Mechanical Thrombectomy in Patients With Ischemic Stroke With Prestroke Disability. *Stroke* 2020;51:1539–1545. doi: 10.1161/STROKEAHA.119.028246
38. de Havenon A, Castonguay A, Nogueira R, Nguyen TN, English J, Satti SR, Veznedaroglu E, Saver JL, Mocco J, Khatri P, et al. Prestroke disability and outcome after thrombectomy for emergent anterior circulation large vessel occlusion stroke. *Neurology*. 2021;97:e1914–e1919. doi: 10.1212/WNL.0000000000012827
39. Holloway RG, Arnold RM, Creutzfeldt CJ, Lewis EF, Lutz BJ, McCann RM, Rabinstein AA, Saposnik G, Sheth KN, Zahuranec DB, et al; American Heart Association Stroke Council, Council on Cardiovascular and Stroke Nursing, and Council on Clinical Cardiology. Palliative and end-of-life care in stroke: a statement for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2014;45:1887–1916. doi: 10.1161/STR.0000000000000015
40. Goldhoorn RB, Verhagen M, Dippel DWJ, van der Lugt A, Lingsma HF, Roos Y, Majoie C, Vos JA, Boiten J, van Zwam WH, et al. Safety and outcome of endovascular treatment in prestroke-dependent patients. *Stroke*. 2018;49:2406–2414. doi: 10.1161/STROKEAHA.118.022352
41. Regenhardt RW, Young MJ, Etherton MR, Das AS, Stapleton CJ, Patel AB, Lev MH, Hirsch JA, Rost NS, Leslie-Mazwi TM. Toward a more inclusive paradigm: thrombectomy for stroke patients with pre-existing disabilities. *J Neurointerv Surg*. 2021;13:865–868. doi: 10.1136/neurintsurg-2020-016783
42. Petrea RE, Beiser AS, Seshadri S, Kelly-Hayes M, Kase CS, Wolf PA. Gender differences in stroke incidence and poststroke disability in the Framingham heart study. *Stroke*. 2009;40:1032–1037. doi: 10.1161/STROKEAHA.108.542894
43. Prakapenia A, Gruener C, Winzer S, Barlinn J, Gerber J, Pallesen LP, Siepmann T, Moustafa H, Reichmann H, Linn J, et al. Misjudgment of prestroke functional status contradicts beneficial outcomes after endovascular therapy for large vessel occlusion. *J Neurol*. 2019;266:2060–2065. doi: 10.1007/s00415-019-09384-z