Visual Aids for Patient, Family, and Physician Decision Making About Endovascular Thrombectomy for Acute Ischemic Stroke

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Background and Purpose—Rapid decision making optimizes outcomes from endovascular thrombectomy for acute cerebral ischemia. Visual displays facilitate swift review of potential outcomes and can accelerate decision processes.

Methods—From patient-level, pooled randomized trial data, 100 person-icon arrays (Kuiper–Marshall personographs) were generated showing beneficial and adverse effects of endovascular thrombectomy for patients with acute cerebral ischemia and large vessel occlusion using (1) automated (algorithmic) and (2) expert-guided joint outcome table specification.

Results—For the full 7-category modified Rankin Scale, thrombectomy added to IV tPA (intravenous tissue-type plasminogen activator) alone had number needed to treat to benefit 2.9 (95% confidence interval, 2.6–3.3) and number needed to harm 68.9 (95% confidence interval, 40–250); thrombectomy for patients ineligible for IV tPA had number needed to treat to benefit 2.3 (95% confidence interval, 2.1–2.5) and number needed to harm 100 (95% confidence interval, 62.5–250). Visual displays of treatment effects on 100 patients showed: with thrombectomy added to IV tPA alone, 34 patients have better disability outcome, including 14 more normal or near normal (modified Rankin Scale, 0–1); with thrombectomy for patients ineligible for IV tPA, 44 patients have a better disability outcome, including 16 more normal or nearly normal. Displays also showed that harm (increased modified Rankin Scale final disability) occurred in 1 of 100 patients in both populations, mediated by increased new territory infarcts. The person-icon figures integrated these outcomes, and early side-effects, in a single display.

Conclusions—Visual decision aids are now available to rapidly educate healthcare providers, patients, and families about benefits and risks of endovascular thrombectomy, both when added to IV tPA in tPA-eligible patients and as the sole reperfusion treatment in tPA-ineligible patients. (Stroke. 2018;49:90-97. DOI: 10.1161/STROKEAHA.117.018715.)

Key Words: decision making ■ decision support techniques ■ health personnel ■ reperfusion ■ thrombectomy

In acute cerebral ischemia because of large vessel occlusion (LVO), endovascular thrombectomy is a highly effective treatment that is now standard of care. Moreover, the degree of benefit from endovascular thrombectomy is highly time dependent. For every 1 minute that therapy is delayed in a typical large artery ischemic stroke, 2 million more brain cells die; for every 4 minutes that therapy is delayed between emergency department arrival and reperfusion, 1 of every 100 patients has a worse disability outcome. For this reason, the national ideal target for the time interval from patient arrival in the emergency department to arterial puncture is <60 minutes.

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During the first minutes after emergency department arrival, much of the time is necessarily devoted to initial diagnostic, stabilizing, and fibrinolytic care, leaving only a brief interval for treatment decision counseling about endovascular thrombectomy. In that brief span, lay individuals must rapidly agree to or decline an endovascular procedure that has substantial potential benefits, but also important potential risks, for a condition that often erupted suddenly and unexpectedly only tens of minutes earlier. Extended and recurrent discussions, appropriate in nonacute settings, are potentially perilous in acute stroke because of the further progression of brain injury that occurs throughout the period of deliberation. Efficiently giving patients essential information to make decisions about emergency treatments is critical for optimal outcome. Figural displays can enable patients, family, and healthcare providers to rapidly understand response patterns to therapy. Developing visual decision aids for acute stroke decisions is challenging because outcomes are along a spectrum of disability, not dichotomized. But techniques to convert ordinal disability outcomes to rapidly legible figural displays have been developed for intravenous fibrinolytic treatment. We undertook to develop similar displays for endovascular thrombectomy based on pooled individual patient-level data from pivotal clinical trials.

**Methods**

**Data Transparency and Ethics Approval**

All data, analytic methods, and study materials used in this investigation are publicly available through the University of California, Los Angeles Stroke Unlocked Data Access platform. No patients were enrolled in this study, and all participating experts were study investigators not study subjects. The analyses were performed on publicly available, aggregate group outcome data without any analysis of patient-level data and without any access to patient-level identifiers. Accordingly, this study did not require either ethics approval or institutional review board waiver.

**Number Needed to Treat and Benefit per Hundred Derivations**

We analyzed pooled data from 5 pivotal trials of endovascular thrombectomy combined at the individual patient data level by the HERMES Collaboration (Highly Effective Reperfusion Evaluated in Multiple Endovascular Stroke). Separate analyses were performed for patients who were eligible and ineligible for IV tPA (intravenous tissue-type plasminogen activator). For IV tPA-eligible patients, we analyzed outcomes of endovascular thrombectomy added to IV tPA versus IV tPA alone; for IV tPA-ineligible patients, we analyzed outcomes of endovascular thrombectomy added to standard medical care versus standard medical care alone. From this data, we generated a 100 person-icon arrays (Kuiper–Marshall personographs) displaying treatment outcomes with thrombectomy versus no thrombectomy.

For dichotomized outcomes, benefit per hundred (BPH) and harm per hundred (HPH) values as a result of intervention were characterized using the absolute risk reductions reported in the pooled analysis. Ordinal outcomes were also analyzed of shift to less or more disability, both over all 7 disability levels of the entire modified Rankin Scale (mRS) and over a 6-level version of the mRS in which severe disability (mRS, 5) and death (mRS, 6) were combined into a joint worst outcome category. The 6-level mRS analysis was performed because nearly half of individuals at risk for stroke do not consider an mRS of 5 (severe disability, bedridden, incontinent, and requiring constant nursing care and attention) to be a better outcome than an mRS of 6 (dead). In the ordinal analysis, BPH was defined as the proportion of patients whose 3-month disability outcome is reduced as a result of therapy by ≥1 steps on the mRS. HPH was defined as the proportion of patients whose 3-month disability outcome is increased as a result of therapy by ≥1 steps on the mRS. Ordinal BPH and HPH were derived using the method of expert population of joint outcome tables. Net ordinal BPH was also calculated using 2 mathematical, automated techniques: (1) the permutation method, and (2) algorithmic min–max population of the joint outcome table. The results of the permutation and automated joint outcome table methods were averaged to provide a single automated technique value.

For the expert joint outcome table method, joint outcome tables were independently populated by 11 content experts, including noninvasive vascular neurologists, emergency physician-neurologists, and neuro-interventionalists. All were academic physicians with extensive research and clinical experience in neurothrombectomy. Each expert populated 2 joint outcome tables, including one for a model population of 100 patients matching the HERMES tPA-eligible patient population and the other for 100 patients matching the HERMES tPA-ineligible patient population. Each expert produced arrays of individual patient responses to treatment for what they believed to be the most biologically plausible results that matched observed trial results. Each expert was instructed to choose the array of individual patient responses that, in their judgment, was the most biologically plausible response pattern, constrained by the requirement that the distribution be consistent with group-level meta-analysis results. The experts were presented with the rate of symptomatic intracranial hemorrhage (SICH) and the rate of new territory infarct that was derived from HERMES-pooled analysis and individual trial data.

Each panel member was given a spreadsheet (Excel; Microsoft Corp, Seattle, WA) displaying the following: (1) definitions of each mRS outcome category; (2) the distribution of mRS outcomes in the thrombectomy and nonthrombectomy groups in the HERMES meta-analysis, rounded to the nearest integer; (3) the rates of SICH in the thrombectomy and nonthrombectomy groups; and (4) the rates of infarct in new territories in the thrombectomy and nonthrombectomy groups. SICH values were based on SICH rates reported by each of the 5 trials using trial-specific, but generally similar, definitions. On the expert spreadsheet, the definition of SICH was described as the definitions of the 5 trials, generally including a ≥4 change on the National Institutes of Health Stroke Scale. Rates of SICH specific for patients treated with concomitant IV tPA and patients ineligible for IV tPA were obtained from the HERMES database and were for tPA-eligible patients: 4% with thrombectomy plus tPA and 4% with tPA alone; for tPA-ineligible patients, 0% with thrombectomy and 0% with standard medical care alone. From the 5 pivotal trials of endovascular thrombectomy, rates of new territory infarct were available for the thrombectomy arm of 4 trials (MR CLEAN [Multicenter Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands], ESCAPE [Evaluation Study of Congestive Heart Failure and Pulmonary Artery Catheterization Effectiveness], EXTEND IA [Extending the Time for Thrombolysis in Emergency Neurological Deficits–Intra-Arterial], and REVASCAT [Randomized Trial of Revascularization With Solitaire FR Device Versus Best Medical Therapy in the Treatment of Acute Stroke due to Anterior Circulation Large Vessel Occlusion Presenting Within Eight Hours of Symptom Onset]) and from the control for 2 trials (MR CLEAN and ESCAPE). Taking a sample size–weighted average, new territory infarct rates were 5% with thrombectomy and 2% with standard medical care. Because rates were not separately reported for patients treated with and patients ineligible for IV tPA, these overall new territory infarct rates were presented for both settings. Experts used the rates of SICH and infarct in new territory to inform their decision making in populating the joint outcome table.

**Construction of Person-Icon Figures**

Based on the above analyses and original pooled analysis data, we constructed 2 broad types of figures: (1) choice consequence, and (2) comparison visual displays. In choice consequence matrices, the graphic takes the outcomes under treatment choice A as a given and
shows the changes in these outcomes that would result from treatment choice B. In outcome distribution comparisons, the full range of outcomes under treatment choice A and treatment choice B are shown adjacent to each other. We considered the choice consequence displays the leading figures and the comparison displays as optional alternatives.

The choice consequence displays were Kuiper–Marshall personographs that show the relative benefit and relative harm of the thrombectomy intervention. Separate visual decision aids were created for the different populations of thrombectomy recipients: tPA-eligible and tPA-ineligible patients. The figures showed changes in outcome as a result of treatment, using the mean BPH and HPH values of the expert joint outcome tables. In the lead 100 person-icon arrays, color shading was used to depict 3 broad changes in long-term, 3-month disability outcomes that occur among 100 treated patients as a result of thrombectomy versus no thrombectomy: (1) having a less disabled outcome with thrombectomy than no thrombectomy, by ≥1 levels on the mRS (green color); (2) having no changes in 3-month disability outcome (white color); and (3) having a more disabled outcome with thrombectomy than no thrombectomy, by ≥1 levels on the mRS (red color). The green icons were further differentiated to show the proportion of patients improving to freedom from all disability, mRS 0 to 1, as a result of treatment (dark green) and improving to lesser levels of disability (light green); and the red icons were further differentiated to show the proportion of patients worsening to severe disability or death, mRS 5 to 6, as a result of treatment (dark red) and worsening to lesser levels of disability (light red). In addition, closed and open dashes were used to depict 2 short-term outcomes that occur among 100 treated patients as a result of thrombectomy versus no thrombectomy: (1) symptomatic intracranial hemorrhage, and (2) infarct in new territory. The proportion of patients with symptomatic intracranial hemorrhage as a result of thrombectomy were indicated by person-icons with closed dashes and the proportion of patients with infarct in new territory as a result of thrombectomy by person-icons with open dashes.

Additional choice consequence figures were created that highlight alternative benefit–harm aspect perspectives that some physicians and healthcare providers may prefer to use in discussion with patients and family. In 1 set of figures, the dark green shading, emphasizing the subset of improvements to a particular dichotomized favorable outcome category, depicted improvements to functional independence (mRS, 0–2) rather than freedom from disability (mRS, 0–1). In another figure set, BPH and HPH are shown considering the 6-level, rather than 7-level version, in which of severe disability (mRS, 5) and death (mRS, 6) are combined into a single worst possible outcome category.

The comparison visual displays consisted of two 100 person-icon arrays that presented 90-day mRS outcomes side-by-side for the thrombectomy and no thrombectomy treatment options. In both arrays, each person-icon is assigned an mRS level based on the group distribution of the 7 mRS levels in the HERMES-pooled analysis. To communicate the degree of disability associated with each level of the mRS, the following color gradient was used: mRS 0, dark green; mRS 1, medium green; mRS 2, light green; mRS 3, yellow; mRS 4, light red; mRS 5, medium red; mRS 6, dark red. Under this approach, mRS outcomes were communicated with both broad and granular dichotomizations: favorable outcomes were broadly colored green (and further differentiated to show the proportion of patients improving to freedom from all disability, mRS 0 to 1), intermediate outcomes broadly colored yellow, and unfavorable outcomes broadly colored red (and further differentiated by intensity of red shading). The comparison visual displays have the advantage of visualizing actual treatment outcomes in both treatment arms simultaneously. However, they do not focus viewer attention directly on the changes in outcome directly because of thrombectomy treatment, and the extra information conveyed may be more challenging for patients and families to process quickly.

Results

In the pooled HERMES analysis, there were 1090 patients (525 randomized to thrombectomy) concomitantly treated with tPA and 188 (108 randomized to thrombectomy) patients who were tPA ineligible. Among the patients receiving background tPA, the mean mRS score in the endovascular thrombectomy plus tPA group was 2.87 (SD, 1.8) and in the tPA-alone group 3.60 (SD, 1.7), yielding a mean difference of 0.73. For concomitant tPA patients, net BPH patients treated values for each of the 6 possible dichotomizations of the mRS are shown in Table and ranged from 0 to 19. Among the patients ineligible for tPA, the mean mRS score in the endovascular thrombectomy was 3.12 (SD, 2.0) and in the nothrombectomy group 3.925 (SD, 1.7), yielding a mean difference of 0.805. For tPA-ineligible patients, net BPH patients treated values for the 6 possible dichotomizations of the mRS ranged from 0 to 32 (Table).

For the concomitant tPA patients, the independent expert joint outcome analyses indicated that the biologically most plausible BPH, of patients having a better outcome with thrombectomy by ≥1 levels on the mRS, was 34.1 (95% confidence interval [CI], 29.8–38.4) and the HPH 1.45 (95% CI, 0.4–2.5; Table). The likelihood of help to harm ratio was 23.5. The net BPH from the expert Joint Outcome Table (eJOT) analysis was 32.6, similar to the automatically derived net BPH of 33.6. The number needed to treat to benefit was 2.9
(95% CI, 2.6–3.3), and number needed to treat to harm was 68.9 (95% CI, 40–250).

Combining the eJOT full mRS shift and eJOT mRS 0 to 2 versus 3 to 6 findings, the BPH analysis indicated that among 100 patients treated with thrombectomy added to tPA rather than tPA alone, 34 have a reduced final level of disability as a result of treatment, including 20 who improve to an independent functional outcome (mRS, 0–2) and 14 whose final disability reduction occurs across other transitions on the mRS besides the mRS 3 to 2 transition (Figure 1). The eJOT HPH analysis also indicated that, among these 100 treated patients, 1 would have an increased final level of disability as a result of thrombectomy, including 0 who worsen to a severely disabled or dead (mRS, 5–6) outcome and 1 whose final disability worsening occurs across other transitions on the mRS besides the mRS 4 to 5 transition. These values were used to generate the lead decision matrix visual decision aid for patients treated with IV tPA (Figure 1).

For the tPA-ineligible patients, the independent expert joint outcome analyses indicated that the biologically most

Figure 1. Choice consequence matrix type visual decision aid depicting the benefits and risks of endovascular thrombectomy added to intravenous tPA (tissue-type plasminogen activator) vs intravenous (IV) tPA alone. Dark green, attainment of excellent outcome (modified Rankin Scale [mRS], 0–1) as a result of thrombectomy; light green, improved disability outcome (other than excellent outcome) as a result of thrombectomy; dark red, severely disabled or dead outcome (mRS, 5–6) as a result of thrombectomy; light red, worse disability outcome (other than severely disabled/dead) as a result of thrombectomy; closed dash, symptomatic intracranial hemorrhage as a result of thrombectomy; open dash, infarct in new territory as a result of thrombectomy. SICH indicates symptomatic intracranial hemorrhage.
plausible BPH, of patients having a better outcome with thrombectomy by ≥1 levels on the mRS, was 43.9 (95% CI, 39.9–47.8) and the HPH 1.0 (95% CI, 0.4–1.6; Table). The likelihood of help to harm ratio was 43.9. The net BPH from the eJOT analysis was 42.9, mildly higher than the automatically derived net BPH of 36.8. The number needed to treat to benefit was 2.3 (95% CI, 2.1–2.5), and number needed to treat to harm was 100 (95% CI, 62.5–250).

Combining the eJOT full mRS shift and eJOT mRS 0 to 2 versus 3 to 6 findings, the BPH analysis indicated that, among 100 patients treated with thrombectomy among tPA-ineligible patients rather than medical therapy alone, 44 have a reduced final level of disability as a result of treatment, including 22 who improve to an independent functional outcome (mRS, 0–2) and 22 whose final disability reduction occurs across other transitions on the mRS besides the mRS 3 to 2 transition. The eJOT HPH analysis also indicated that, among these 100 treated patients, 1 would have an increased final level of disability as a result of thrombectomy, including 0 who worsen to a severely disabled or dead (mRS, 5–6) outcome and 1 whose

Figure 2. Choice consequence matrix type visual decision aid depicting the benefits and risks of endovascular thrombectomy among tPA (tissue-type plasminogen activator)–ineligible patients. Dark green, attainment of excellent outcome (modified Rankin Scale [mRS], 0–1) as a result of thrombectomy; light green, improved disability outcome (other than excellent outcome) as a result of thrombectomy; dark red, severely disabled or dead outcome (mRS, 5–6) as a result of thrombectomy; light red, worse disability outcome (other than severely disabled/dead) as a result of thrombectomy; closed dash, symptomatic intracranial hemorrhage as a result of thrombectomy; and open dash, infarct in new territory as a result of thrombectomy. SICH indicates symptomatic intracranial hemorrhage.
Discussion

In this study, visual decision aids have been generated to assist patients, families, and clinicians in acute thrombectomy decision making that depict benefits and harms of intervention over all levels of final disability, as well as incorporating short-term adverse effects of symptomatic intracranial hemorrhage and infarct in new territory. Calculations of the BPH- and HPH-treated patients considering disability transitions across all 7 levels of the mRS showed good agreement between automated, mathematical derivations and expert-informed derivations. For tPA-treated patients, the expert-assisted derivation indicated that, for every 100 treated patients, 34 will have a better and 1 a worse outcome by ≥1 levels on the mRS global disability scale. Benefits were even greater for tPA-ineligible patients, among whom the expert-assisted derivation indicated that for every 100 treated patients, 44 will have a better and 1 a worse outcome by ≥1 levels on the mRS global disability scale. Clinicians can use visual decision aids displaying these and related in the acute setting to expeditiously inform patients and family members of the benefits and risks associated with endovascular thrombectomy for acute ischemic stroke.

The visual displays generated in this study meet the recommendations of the International Patient Decision Aids Collaboration and related best-practice recommendations for developing high-quality decision aids that are particularly relevant for emergency treatments.\(^8\,12\) Criteria satisfied include (1) figure design generation included input from disease-specific experts; multiple medical specialties; health outcomes researchers; and patients with stroke;\(^8\); (2) data sources are identified, and figure is based on highest grade available evidence; (3) graph type is appropriate to the information being conveyed (eg, Kuiper–Marshall iconographs for comparisons among groups); (4) both benefits and risks are shown; (5) similar outcomes are shown in similar manner across treatment groups; (6) graphic display elements are proportional to the quantities depicted; (7) figure displays absolute indices, not relative indices, of benefit and harm and compares outcome probabilities using the same denominator; and (8) outcomes generally valued by patients as differentially important are differentially emphasized graphically (eg, by color, font size, etc). By conveying information about 4 long-term and 2 short-term outcomes concisely in a single graphic, the leading figure informs patients and family, at a glance, about key benefits and risks of therapy, promoting rapid decision making.

Our study extends prior work in acute stroke treatment visual decision aids. It most directly complements the decision aid with a similar format that our group developed for IV tPA treatment within 3 hours of onset versus supportive medical care.\(^9\) Of note, the number of patients per hundred shown benefitting by attaining reduced degree of disability in the current choice consequence figures as a result of endovascular thrombectomy, for tPA-treated and for tPA-ineligible patients (34 and 44, respectively), are only modestly higher than that shown in the prior figure for IV tPA within 3 hours versus supportive care (32). It is important to interpret these numbers in light of the much broader populations being offered IV tPA than being offered endovascular thrombectomy. Patients treated with IV tPA broadly include many patients with occlusions in small penetrating and medium superficial arteries, of low thrombus burden, that respond well to pharmacological fibrinolytic therapy. In contrast, patients being offered endovascular thrombectomy include only patients with occlusions in large arteries, of high thrombus burden, that respond poorly to IV tPA. Values for the benefit of IV tPA alone derived for the population of all tPA-eligible patients, including both non-LVO and LVO ischemic strokes, will overstate the benefit of IV tPA for the less responsive LVO patient subgroup. The substantial added value of thrombectomy in LVO patients is indicated by the high BPH value for endovascular thrombectomy when added to IV tPA in the current figures.

Although the reperfusion rate with IV tPA in large artery occlusions is low, it is nonzero, and our findings indicate that IV tPA alone does confer a modest benefit in this population. This effect is reflected in the lower benefit magnitude in the comparison of thrombectomy added to IV tPA versus IV tPA alone in tPA-eligible patients (34 of 100 patients achieved reduced disability) compared with thrombectomy alone versus supportive medical therapy in tPA-ineligible patients (44 of 100 patients achieving reduced disability). When thrombectomy plus IV tPA is being contrasted to IV tPA alone, the control group is an active comparator that does receive intravenous fibrinolytic reperfusion therapy with some resulting benefit, reducing the proportion of patients otherwise destined for poor outcomes whom thrombectomy can benefit. When thrombectomy alone is being contrasted to only supportive medical care, the control group does not receive any reperfusion therapy, increasing the proportion of patients otherwise destined for poor outcomes whom thrombectomy can benefit.

Although there has been extensive prior work developing visual decision aids for intravenous tPA,\(^8\,13\,14\) few prior studies have yet developed decision aids for endovascular thrombectomy. A pioneering study developed a visual decision aid also based on the HERMES data set.\(^15\) However, the figure generated had some drawbacks. The figure showed only 1 mRS transition, rather than all disability state transitions, so substantially underestimates the true net benefit of therapy;
does not show SICH or infarct in new territory; shows only net benefit with treatment, not both absolute benefit and absolute harm; uses figure coloring psychophysically discrepant with actual outcomes being conveyed, with many of the red (suggesting adverse) outcomes actually being good outcomes; and did not differentiate thrombectomy added to tPA and thrombectomy in tPA-ineligible patients. In contrast, the figures in the current study convey this information.

A drawback of both the prior and the current figures for endovascular thrombectomy decision making is that they show group differences in outcome for a broad population. A particular patient with particular prognostic and treatment response features, including age, National Institutes of Health Stroke Scale score, time from onset, imaging infarct core size, etc, will have patient-specific expected outcomes with and without thrombectomy not fully captured in a uniform, group display. Techniques have been developed to generate tailored, patient-specific visual decision aids in real-time based on patient-presenting characteristics and have been applied to IV tPA and other cardiovascular decision making although not endovascular thrombectomy. However, to date these have focused on dichotomous outcomes and so underestimate the true benefits and harms of therapy. It would be desirable to develop tailored displays that would show patient-specific expected ordinal outcomes with endovascular thrombectomy. Such display generation requires access to patient-level, rather than study-level, trial data and should become possible in the coming years because the trial data sets become more publicly available.

In the current study, in addition to the lead visual decision aids, we also generated supplementary choice consequence decision aids. These additional aids are useful for clinicians who feel it is best to collapse mRS 5 to 6 into a single category or who prefer to emphasize outcomes of mRS 0 to 1 as a result of treatment. The magnitude of absolute benefit of thrombectomy in increasing the proportion of patients with mRS 0 to 1 outcomes was generally similar to that for increasing mRS 0 to 2 outcomes. We also developed comparison displays for use by clinicians who prefer side-by-side comparisons of the treatment arms; however, these double arrays may be somewhat complex for patients and families to rapidly process and understand, in comparison with the accessible, single-array, choice consequence figures.

An additional aspect of the decision aid figures for thrombectomy that differs from the prior figures developed of IV tPA versus medical therapy is the driver of harmful final outcome, defined as worse disability level at 3 months. In the IV tPA versus medical therapy figures, the genesis of long-term harm was an increased rate of early symptomatic intracranial hemorrhage in patients treated with IV tPA versus those treated with supportive medical therapy. In contrast, for the current thrombectomy figures, early symptomatic intracranial hemorrhage did not contribute to the long-term harm outcomes because SICH occurred equally frequently in the thrombectomy and nonthrombectomy groups. Rather, long-term harm outcomes arose from an increase in infarcts in new territories with thrombectomy.

This study has limitations. Data were available about symptomatic intracranial hemorrhage rates with and without thrombectomy in the separate populations of patients treated with IV tPA and IV tPA–ineligible patients. However, data on rates of infarct in new territory with and without thrombectomy were available only for the combined population, including intermingled patients treated with IV tPA and IV tPA–ineligible patients. In addition, the visual figures in the current study were generated from pooled randomized clinical trial data. The benefits and harms displayed may not be fully generalizable to patients who would not have trial entry criteria or patients being treated at less experienced endovascular centers. Conversely, if endovascular thrombectomy technology substantially improves over current generation techniques improve, yielding higher reperfusion rates and better outcomes, the current figures will underestimate treatment benefit. The visual aid options developed in this study have not yet been comparatively tested in actual practice, and it is not known which of the alternative formats presented will be preferred by users. Last, the visual displays presented here are intended to support thrombectomy decision making and supplement, rather than replace, patient–practitioner discussions.

Conclusions

Endovascular thrombectomy is a treatment for acute cerebral ischemia because of LVOs that has substantial long-term benefit, reducing disability in 34% to 44% of treated patients, and minimal long-term harm, increasing disability in 1% of patients. Visual displays are now available that integrate, in a single, accessible figure, long-term benefits, long-term harms, and short-term complications. These decision aids can convey the health benefits and risks of thrombectomy treatment efficiently to patients, family members, and physicians, facilitating rapid, informed decision making and improved stroke outcomes. These displays may also be useful in public education and in education of policy makers to facilitate understanding of the magnitude of benefit and harm of thrombectomy for stroke.

Disclosures

Dr Demchuk received honoraria from Medtronic for continuing medical education lectures. Dr Froehlicher is a consultant to Medtronic, Stryker, Control Medical, and Blockade/Balt Medical. Dr Goyal is a consultant to Medtronic, Stryker, Microvention, and Ablynx. Dr Jahan is a consultant to Medtronic Neurovascular. Dr Liebeskind is a consultant to Stryker and Medtronic. Dr Lutsep is on the Executive Committee for the National Institute of Neurological Disorders and Stroke–funded DEFUSE3 trial (Endovascular Therapy Following Imaging Evaluation for Ischemic Stroke 3). Dr Starkman is a site investigator in multicenter trials supported by the National Institutes of Health, Stryker, Biogen Idec, Neuravi, Genentech, Coviden, and Astra-Zeneca. University of California (UC) Regents received payments on the basis of clinical trial contracts for the number of subjects enrolled. The University of California has patent rights in retrieval devices for stroke. Dr Saver has served as an unpaid site investigator in multicenter trials supported by Medtronic and Stryker for which the UC Regents received payments on the basis of clinical trial contracts for the number of subjects enrolled. Dr Saver receives funding for services as a scientific consultant regarding trial design and conduct to Medtronic, Stryker, Neuravi, and Boehringer Ingelheim (prevention only). Dr Saver is an employee of the University of California: the University of California has patent rights in retrieval devices for stroke. Dr Schwamm reports research support from National Institutes of Health for the MR Witness trial for which Genentech
provided alteplase free of charge and modest site supplemental payments; serves as a consultant in in the atrial fibrillation trial design for Medtronic. I. Tokunboh is an employee of the University of California: the University of California has patent rights in retrieval devices for stroke. The other authors report no conflicts.

References


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SUPPLEMENTAL MATERIAL


Supplementary Figure I: Changes in Outcome Due to Thrombectomy Plus tPA vs tPA Alone
Supplementary Figure II: Changes in Outcome Due to Thrombectomy vs No Reperfusion Therapy
Supplementary Figure III: Changes in Outcome Due to Thrombectomy Plus tPA vs tPA Alone (6-level mRS)
Supplementary Figure IV: Changes in Outcome Due to Thrombectomy vs No Reperfusion Therapy (6-level mRS)
Supplementary Figure V: Choice Comparison Display for IV tPA vs Thrombectomy Plus tPA
Supplementary Figure VI: Choice Comparison Display for Medical Treatment Alone vs Thrombectomy Alone
Supplementary Figure I: Changes in Outcome Due to Thrombectomy Plus tPA vs tPA Alone

Thrombectomy Plus tPA vs tPA Alone
(tPA-Eligible Patients)

Changes in final outcome as a result of treatment:
- Normal or nearly normal
- Other improvement
- No major change
- Other worsening
- Severely disabled or dead

Early course:
- New territory infarct
- Early worsening with brain bleeding (SICH)*

(*No difference in the rate of SICH due to thrombectomy)
Supplementary Figure II: Changes in Outcome Due to Thrombectomy vs No Reperfusion Therapy

Thrombectomy vs No Reperfusion Therapy (tPA-Ineligible Patients)

Changes in final outcome as a result of treatment:
- Normal or nearly normal
- Other improvement
- No major change
- Other worsening
- Severely disabled or dead

Early course:
- New territory infarct
- Early worsening with brain bleeding (SICH)*

(*No difference in the rate of SICH due to thrombectomy)
Supplementary Figure III: Changes in Outcome Due to Thrombectomy Plus tPA vs tPA Alone (6-level mRS)

Thrombectomy Plus tPA vs tPA Alone (tPA-Eligible Patients) over 6-level mRS

Changes in final outcome as a result of treatment:
- Normal or nearly normal
- Other improvement
- No major change
- Other worsening
- Severely disabled or dead

Early course:
- New territory infarct
- Early worsening with brain bleeding (SICH)*

(*No differences observed in the rate of SICH due to thrombectomy)
Supplementary Figure IV: Changes in Outcome Due to Thrombectomy vs No Reperfusion Therapy (6-level mRS)

Thrombectomy vs No Reperfusion Therapy (tPA-Ineligible Patients) over 6-level mRS

Changes in final outcome as a result of treatment:
- Normal or nearly normal
- Other improvement
- No major change
- Other worsening
- Severely disabled or dead

Early course:
- New territory infarct
- Early worsening with brain bleeding (SICH)*

(*No differences observed in the rate of SICH due to thrombectomy)
Supplementary Figure V: Choice Comparison Display for IV tPA vs Thrombectomy Plus tPA

Intravenous tPA Alone for Cerebral Ischemia (tPA-Eligible Patients)  
Thrombectomy added to tPA for Cerebral Ischemia in (tPA-Eligible Patients)

Legend:
- mRS 0
- mRS 1
- mRS 2
- mRS 3
- mRS 4
- mRS 5
- mRS 6
Supplementary Figure VI: Choice Comparison Display for Medical Treatment Alone vs Thrombectomy Alone

Medical Therapy Alone for Cerebral Ischemia (tPA-Ineligible Patients)

Thrombectomy for Cerebral Ischemia (tPA-Ineligible Patients)

Legend:
- mRS 0
- mRS 1
- mRS 2
- mRS 3
- mRS 4
- mRS 5
- mRS 6