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Visual aid tool to improve decision making in acute stroke care

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Abstract

Background: Acute stroke care represents a challenge for decision makers. Recent randomized trials showed the benefits of endovascular therapy. Our goal was to provide a visual aid tool to guide clinicians in the decision process of endovascular intervention in patients with acute ischemic stroke.

Methods: We created visual plots (Cates' plots; www.nntonline.net) representing benefits of standard of care vs. endovascular thrombectomy from the pooled analysis of five RCTs using stent retrievers. These plots represent the following clinically relevant outcomes (1) functionally independent state (modified Rankin scale (mRS) 0 to 2 at 90 days) (2) excellent recovery (mRS 0–1) at 90 days, (3) NIHSS 0–2 (4) early neurological recovery, and (5) revascularization at 24 h. Subgroups visually represented include time to treatment and baseline stroke severity strata.

Results: Overall, 1287 patients (634 assigned to endovascular thrombectomy, 653 assigned to control were included to create the visual plots. Cates' visual plots revealed that for every 100 patients with acute ischemic stroke and large vessel occlusion, 27 would achieve independence at 90 days (mRS 0–2) in the control group compared to 49 (95% CI 43–56) in the intervention group. Similarly, 21 patients would achieve early neurological recovery at 24 h compared to 54 (95% CI 45–63) out of 100 for the intervention group.

Conclusion: Cates' plots may assist clinicians and patients to visualize and compare potential outcomes after an acute ischemic stroke. Our results suggest that for every 100 treated individuals with an acute ischemic stroke and a large vessel occlusion, endovascular thrombectomy would provide 22 additional patients reaching independency at three months and 33 more patients achieving ENR compared to controls.

Keywords

Acute stroke therapy, outcomes, visual aid tool, tPA, treatment, stroke, thrombolysis, endovascular therapy, decision making

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Background

Management of acute ischemic stroke care has recently changed with the demonstration of efficacy of endovascular therapy. Recent meta-analysis and pooled analysis from these trials consistently revealed benefits of adjunct

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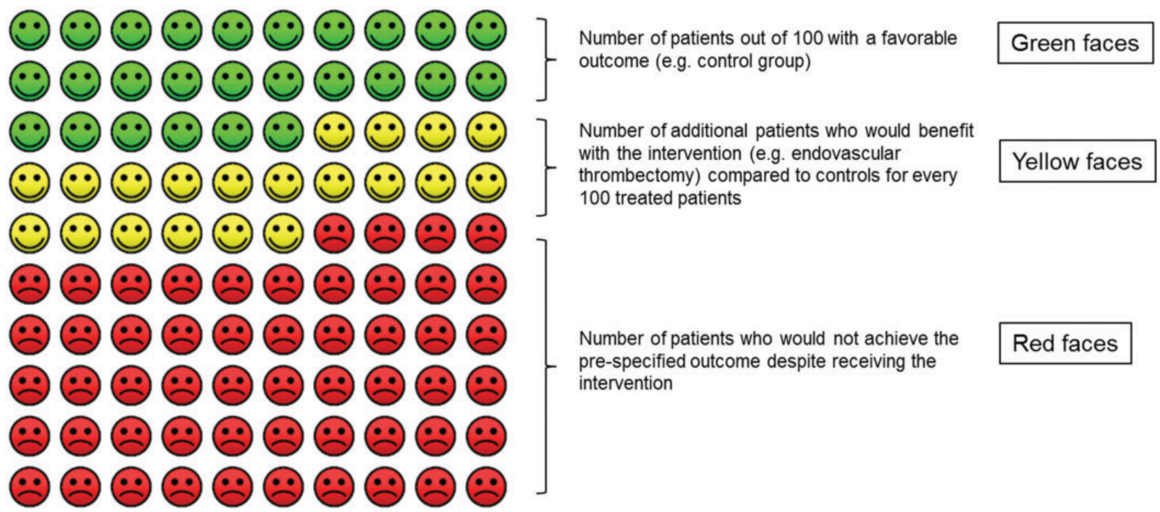
Figure 1. Schematic interpretation of Cates' plots, (nntonline.net/visualrx/cates_plot/).



endovascular and thrombolytic therapies. Visual aid tools to better inform and counsel stroke patients and their families about the best therapeutic strategy can provide a personalized-medicine approach to decision making.

Some studies suggest the use of visual aid tools would include patients' perspectives taking into account the increasing attention to patient-centered care and outcomes.[1,2] However, it is important to identify relevant factors that influence stroke outcomes, including age, stroke severity, baseline imaging, time from symptoms onset, and comorbid conditions.

Most decisions in acute stroke care require an estimation of the expected outcome with imperfect information (under uncertainty).[3]

Our goal was to provide a visual aid tool to guide clinicians caring for patients with an acute ischemic stroke in making decisions regarding endovascular therapy. In addition, we compared the results of individual pooled analysis with a meta-analysis to evaluate differences in effect size estimates.

Methods

A Cates' plot (nntonline.net/visualrx/cates_plot/) is a decision tool to visually illustrate and communicate the risks and benefits of treatments per 100 or 1000 patients.[4] A Cates' plot includes four smiley face categories to visually depict patients outcomes (green faces for those achieving the specified outcome and red for those not achieving the specified outcome), additional benefits of treatment compared to controls (yellow faces), and people with an adverse event that changes from a good outcome to bad outcome (crossed out green faces) (Figure 1 and the supplemental material, available online with this article). Cates' plots were created based on the crude estimates in the control group and adjusted ORs (95% CI) when available.

We created Cates' plots derived from a recent pooled analysis comprising individual patient-data from five randomized trials of endovascular thrombectomy (EVT) compared to usual care (HERMES trials).[5] We considered favorable functional outcome defined as a modified Rankin scale (mRS) of 0 to 2 at 90 days. Secondary outcomes were mRS 0–1 at 90 days, National Institutes of Health Stroke Scale (NIHSS) 0 to 2 at 24 h; early neurological recovery (ENR) at 24 h (reduction in NIHSS score of at least 8 points from baseline or reaching 0–1) and revascularization at the end of the endovascular procedure (defined using the modified thrombolysis in cerebral infarction (mTICI) scale score of 2 b or 3—corresponding to reperfusion of at least 50% of the affected vascular territory). Plots were stratified by baseline characteristics (age, sex, NIHSS, and time to treatment). A summary of the included studies is shown in Table 1.

In order to put the results in perspective, we also compared the estimates for a favorable outcome at 90 days (mRS 0–2) with the pooled analysis of tPA trials,[6] a recent meta-analysis of EVT comprising eight studies (Thrombectomy trials),[7] and a pooled analysis including patient-level data elements of four different trials:[8] NINDS tPA stroke studies (Part I and II), the solitaire flow restoration device versus the merci retriever in patients with acute ischemic stroke (SWIFT),[9] and the solitaire flow restoration thrombectomy for acute revascularization (STAR) (single arm study).[10] The aim of this comparison was to determine differences in estimates when applying different methodologies

Table 1. Main characteristics of randomized studies of endovascular thrombectomy

	MR CLEAN	ESCAPE	EXTEND IA	SWIFT PRIME	REVASCAT
Number of patients in the intervention arm	233	165	35	98	103
Number of patients in the control arm	267	150	35	98	103
Countries	Netherlands	Multiple	Australia/New Zealand	Multiple	Spain
Imaging criteria					
Modality	NCCT/CTA	NCCT/CTA (CTP optional)	NCCT/CTA/CTP (MRI optional)	NCCT/CTA/CTP (MRI optional)	NCCT/CTA (CTP optional)
Occlusion site	ICA M1 M2	ICA M1	ICA M1 M2	ICA M1	ICA M1
Clinical criteria					
Age (mean or median in years), intervention/ control	66/67	71/70	68.6/70.2	65/66.3	65.7/67.2
NIHSS [mean ± SD or median(IQR)], intervention/control	17 (14–21)/18 (14–22)	16 (13–20)/17 (12–20)	17 (13–20)/13 (9–19)	17 (13–20) 17 (13–19)	17 (14–20)/17 (12–19)
Median time to randomization in min, intervention/control	204/196	169/172	NA	190.5/188	223/226
Groups					
Control group	Standard care	Standard care	Standard care in IV alteplase eligible patients	Standard care in IV alteplase eligible patients	Standard care
IV alteplase (tPA) in the control group	242 (90.6)	118 (78.7)	35 (100)	98 (100)	80 (77.7)
Intervention group, device	Any	Any	Solitaire	Solitaire	Solitaire
IV alteplase (tPA) in the intervention group	203 (87.1)	120 (72.7)	35 (100)	98 (100)	70 (68)

NCCT: non contrast CT; CTA: CT angiography; CTP: CT Perfusion; MRI: magnetic resonance imaging; ICA: internal carotid artery, MCA: middle cerebral artery; NIHSS: national institute of health stroke scale; IV: intravenous

(pooled analysis of individual patient data including RCTs[5] vs. no-RCTs[8] and meta-analysis using global results[7]).

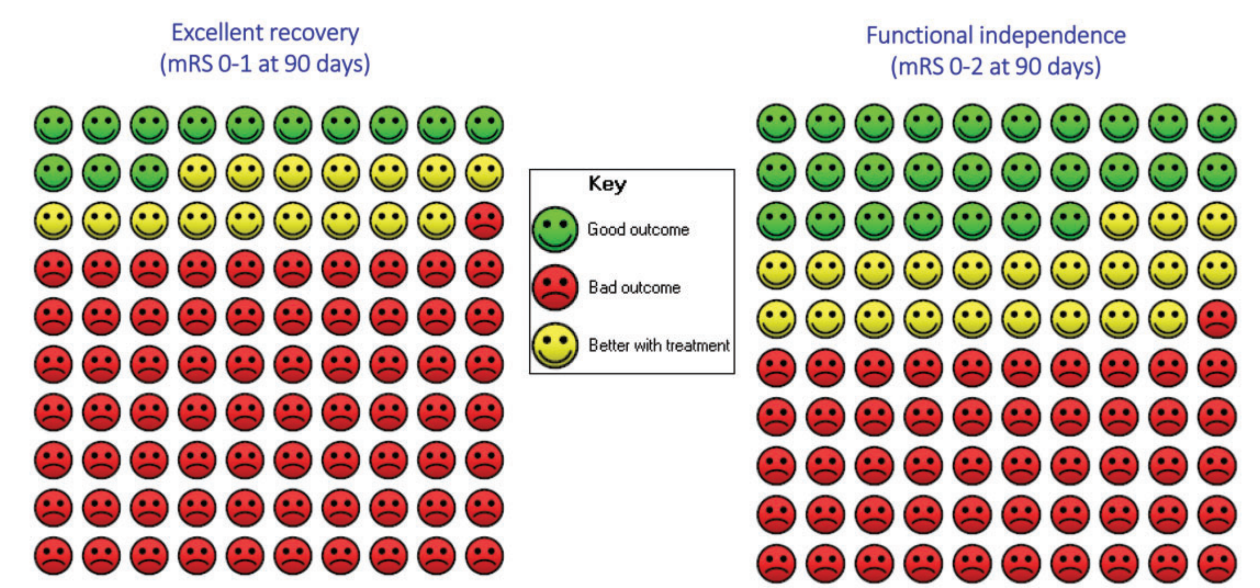
Results

Overall, 1287 participants contributed to the estimates represented by the Cates' plots (supplementary material).[5] Of those, 634 participants were assigned to EVT (intervention group) and 653 assigned to standard medical treatment (control group). The majority of patients also received intravenous tPA (528/634 (83%) in the EVT group and 573/653 (87.7%) in the control group).

For every 100 patients with an acute ischemic stroke, 27 in the control group would achieve independence (mRS 0–2) at 90 days compared to 49 (95% CI 43–56) in the intervention group (Figure 2).

Table 2 summarizes the comparison of main estimates between studies. Of note, the pooled analysis including four studies (NINDS trials, SWIFT and STAR) with higher heterogeneity and diverse populations (e.g. placebo, IV alteplase (tPA), EVT alone, and

Figure 2. Functional outcomes in the pooled analysis of EVT trials.



Excellent recovery (mRS 0–1 at 90 days): In the control group 13 out of 100 patients would gain independence at 90 days (mRS 0–1), compared to 29 (95% CI 23 to 35) out of 100 for the intervention group.
Functional independence (mRS 0–2 at 90 days): In the control group 27 out of 100 patients would achieve independence at 90 days (mRS 0–2) compared to 49 (95% CI 43–56) out of 100 for the intervention group.

Table 2. Comparison of estimates between pooled analysis and meta-analysis of endovascular thrombectomy and tPA trials

	HERMES trials[5]		Thrombectomy trials[7]		Pooled analysis of NINDS, STAR and SWIFT trials[8]	
Study outcome measure	OR (95% CI)	Adjusted OR (95% CI)	OR (95% CI)	Adjusted OR (95% CI)	OR (95% CI)	Adjusted OR (95% CI)
mRS 0–2	2.35 (1.85–2.98)	2.71 (2.07–3.55)	1.71 (1.18–2.49)	NA	NA	4.45 (2.40–8.27)
mRS shift analysis[a]	2.26 (1.67–3.06)	2.49[a] (1.76–3.53)	NA	NA	NA	5.77 (3.59–9.25)
Revascularization at 24 hours	NA	NA	6.49 (4.79–8.79)	NA	NA	NA
Number needed to treat (NNT)	2.6[b]		8		3.1[b]	

[a]Common odds ratio indicating the odds of improvement of 1 point on the mRS.
[b]The NNT for one patient to have reduced disability of at least 1 point on mRS derived from the shift analysis.

IV alteplase (tPA) + EVT) had wider 95% CI estimates.[8] Interestingly, the NNT was similar to the pooled analysis of five RCTs (3.1 vs. 2.6) (Table 2).

The meta-analysis of eight EVT trials provided the lowest estimates in favor of the intervention at 90 days (OR 1.71; 1.18–2.49), with a higher NNT of 8.[7] Endovascular therapy was associated with a 6.5 fold increase in successful revascularization at 24 h. Illustrations using Cates' plots for NIHSS 0–2 at 24 h and early neurological recovery are presented in the supplementary material (Figure II). In addition, subgroup analysis comparing the probability of achieving a favorable outcome (mRS 0–2) by time from symptoms onset (Figure III), NIHSS, age, and sex strata are also depicted (Figures IV(a) and (c)). Revascularization at 24 h and mRS 0–2 in the meta-analysis of the eight EVT trials are also presented (Figure V). The comparison of the pooled analysis of IV alteplase (tPA) trials (vs. placebo) and EVT (vs. usual care) revealed that for every 100 strokes, IV alteplase (tPA) adds 8 more patients who would achieve an mRS 0–1 compared to placebo, whereas EVT would add 16 more patients achieving an mRS 0–1 compared to usual care (IV alteplase(tPA)) (supplementary material, Figures VI). Figure VII compares parenchymal hemorrhage in the pooled analysis of IV alteplase(tPA) trials and EVT trials.

The overall benefits of the intervention group appear more modest (+22 vs. +13 patients would achieve independency) when comparing Cates' plots derived from the pooled analysis (five RCTs) and the meta-analysis of eight studies (supplementary material, Figure VIII).

Discussion

The development of visual tools to aid decision making is complex. There are few visual aid tools available to discuss therapeutic options and prognosis in acute stroke care. Most common pictograms use absolute numbers with a denominator (i.e. per 100 patients or 1000 screened participants) to represent the probability of being diagnosed with a specific medical condition (e.g. breast cancer) or achieving a favorable outcome. This issue became more relevant since the publication of five RCTs of EVT last year. Neither the meta-analysis nor the pooled analysis provided a visual aid to assist patients and clinicians.[5,7] Clinicians, members of stroke teams, patients and their families have difficulty in understanding the meaning of odds ratios or relative risks.[11,12] Visual aid decision tools emerged to overcome this issue.

In the present study, we introduced Cates' plots as a visual aid tool to illustrate the prognosis after EVT or usual care after an acute ischemic stroke. We also depicted the probability of a favorable outcome (mRS 0–2 at 90 days) in relevant subgroups based on time from stroke onset and stroke severity and compared to the pooled analysis of IV alteplase (tPA) trials. This information is particularly useful both when counselling stroke patients and their families and also for continuing medical education of physicians, nurses and technical teams involved in stroke care. For example, Cates' plots show the decline in the expected probability of achieving independency among groups with increasing stroke severity (based on NIHSS). In addition, different case-scenarios were illustrated to represent the additional benefits of EVT compared to usual care or no treatment. We also observed a variation in the estimates derived from the pooled analysis and meta-analysis, which are likely explained by methodological differences (e.g. inclusion of studies, patient-level data vs. summary measures).

Some limitations deserve comment. First, we use information from published meta-analysis to create the plots. As a result, the great majority of participants in the control group received IV alteplase (tPA) (not placebo). To ameliorate this potential concern, we also included a plot to compere the benefits of IV alteplase (tPA) vs. placebo (derived from an updated pooled analysis of IV alteplase (tPA) studies) (appendix, Figure VI).[6] Second, we have no information regarding how the use of this visual aids tool may influence therapeutic decisions regarding in acute stroke care; this is fodder for a future study.

On the other hand, the use of visuals tools providing information on gains and losses of diagnostic or therapeutic options have been shown to change and improve decision making.[13,14] Some studies suggest key components of risk communication when using visual aid tools, including: (1) presenting the chance an event will occur; (2) presenting changes in numeric outcomes (per 100 or 1000 patients); (3) outcome estimates for screening test and therapeutic decisions; (4) numeric estimates; (5) visual formats; (6) narrative methods facilitating the interpretation, among others.[15] Cates' plots fulfill these criteria to enhance the communication of the expected outcome in patients with an acute ischemic stroke.

In conclusion, acute stroke care represents a challenge for decision makers due to time constraints, imperfect clinical information, and the need for evaluation of the best treatment while learning about our patients' preferences and values. Conveying accurate information regarding the expected outcome is crucial when counselling stroke patients and their families. Cates' plots represent a step forward to promptly facilitate information using a visual aid tool to guide therapeutic options in acute stroke care.

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Author's contributions

All authors have participated in the conception, design, analysis, interpretation of results, drafting the manuscript and made critical revisions of the manuscript.

Declaration of conflicting interests

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