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Decision Making in Acute Stroke Care: Learning From Neuroeconomics, Neuromarketing, and Poker Players

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Comments and Opinions

Decision Making in Acute Stroke Care
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Making decisions in medical care is a difficult task, involving a variety of cognitive processes. Decision making is defined as the process of examining possibilities, risks, uncertainties, and options, comparing them, and choosing a course of action.[1,2] Decisions based on erroneous assessments may result in incorrect patient and family expectations, and potentially inappropriate advice, treatment, or discharge planning (eg, longer length of hospitalization, long-term placement, and wasted resources). Rapid and accurate decision making is critical to stroke care, for which several factors have proven effect on outcomes.[3–7] In brief, there are patient-level, hospital-level, and provider-level characteristics that directly affect stroke outcomes (Figure 1).[7,8]

There is limited information on how clinicians make decisions and predict outcomes. Some clinicians apply the knowledge they have acquired from previous experience, others use information available at the time of the assessment, and others use risk score tools or a combination of the above. A better understanding of the decision-making process when treating patients with an acute ischemic stroke could increase clinician awareness of unconscious biases and sources of error and allow the implementation of cognitive shortcuts to make accurate decisions when facing difficult clinical scenarios.

Herein, we review different principles and disproven myths revealed by neuroeconomics and neuromarketing and lessons learned from professional poker players, to assist clinicians in making prompt, rational, and accurate decisions in acute stroke care.

How We Make Decisions?

Neuroeconomics is the science that studies the principles of how we make decisions.[9,10] Neuromarketing is the science that studies consumers' sensorimotor, cognitive, and affective response to marketing stimuli.[11] The neuroscience of decision making is based on statistical methods and mathematical approaches, such as game theory, to predict and to model how people make their own choices.[12] Essentially, there are 2 major types of decisions: (1) programmed: a decision that is repetitive, automatic, and routine and can be made using a systematic approach (eg, most tissue-type plasminogen activator [tPA] decisions in acute stroke) and (2) nonprogrammed: a decision that is unique, individual, or requires a thoughtful analysis (eg, assessing potential risk and benefits in a particular context). Other authors have identified similar categories. For example, decisions may rely on either system 1 (intuitive, unconscious, effortless, fast, and emotional) or system 2 (deliberate, conscious reasoning, slow, and effortful), sometimes referred to as Plato's 2 horses and a chariot.[13] Practical marketing concepts highlight the underlying steps involved in the decision-making process (called 6 Cs of decision making; Figure I in the online-only Data Supplement). In summary, we spend our lives making decisions and helping our patients decide by facilitating information, gathering, and providing counseling.

Understanding Risks: the Amplifying Effect of Aging and Comorbid Conditions

The worldwide population is aging.[14] Data from the United Nations suggest that the number of older patients has tripled in the past 50 years and will triple during the next 50 years (United Nations; http://www.un.org/esa/population/publications/worldageing19502050/index.htm; accessed February 23, 2014). Given the increased prevalence of several stroke risk factors with age (eg, hypertension, atrial fibrillation, and cardiac failure), the longer life expectancy and aging of the population, clinicians will likely face more older patients with stroke and a higher prevalence of a combination of comorbid conditions affecting stroke outcomes.[14,15] As illustrated in Figure 2, our patients carry a medical backpack containing risk factors and comorbid conditions, which becomes heavier with aging.

Some studies suggest that higher risk of death and disability is associated with higher prevalence of comorbid conditions. This phenomenon has been called the amplifying effect of age and comorbidities (Figure 2).[4,16,17] Because some comorbid conditions (ie, cardiac failure and atrial fibrillation) are independent predictors of stroke outcomes, an individual risk assessment is needed.[4,18]

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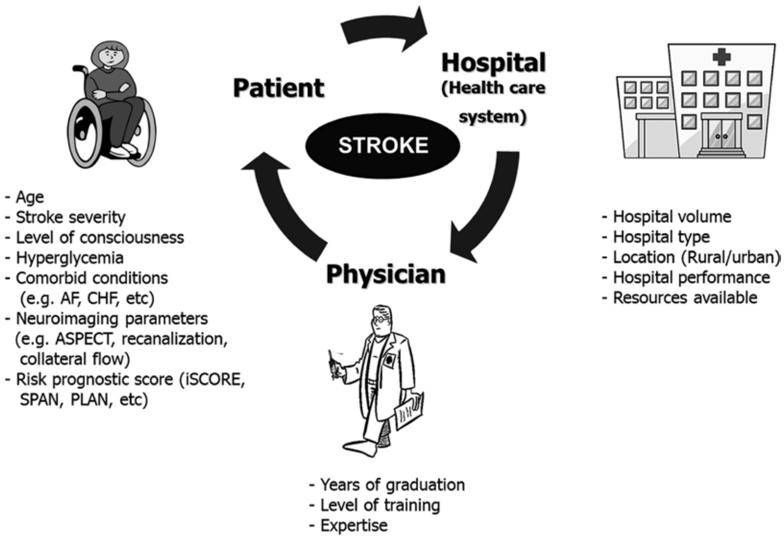

Figure 1. Factors influencing stroke outcomes. AF indicates atrial fibrillation; ASPECT, Alberta Stroke Program Early Computed Tomographic score; and CHF, congestive heart failure.

Figure 3 represents the risk versus the potential benefits of a particular decision. The ideal situation is represented in the lower right quadrant (low risk with a high likelihood of achieving a favorable outcome/reward). For example, the decision of giving thrombolysis to the ideal tPA candidate (eg, young individual, seen <90 minutes from stroke onset with no major comorbid conditions) would fall in the lower right quadrant. A more difficult scenario is represented in the left upper quadrant in which there is a high risk of a complication/undesired outcomes with a low possibility of a favorable outcome. For instance, an 87-year-old man with history of heart and renal failure, cognitive decline living in a nursing home would fall in this complex category, posing lower benefit odds with tPA. Older age and more frequent-associated comorbidities definitely increase the risk of many acute interventions.

Measuring Risk: Learning From Poker Players

Poker is a card game involving the assessment of chances of beating the opponent's hand of cards. The winner is determined by the ranks and combinations of their cards, some of which

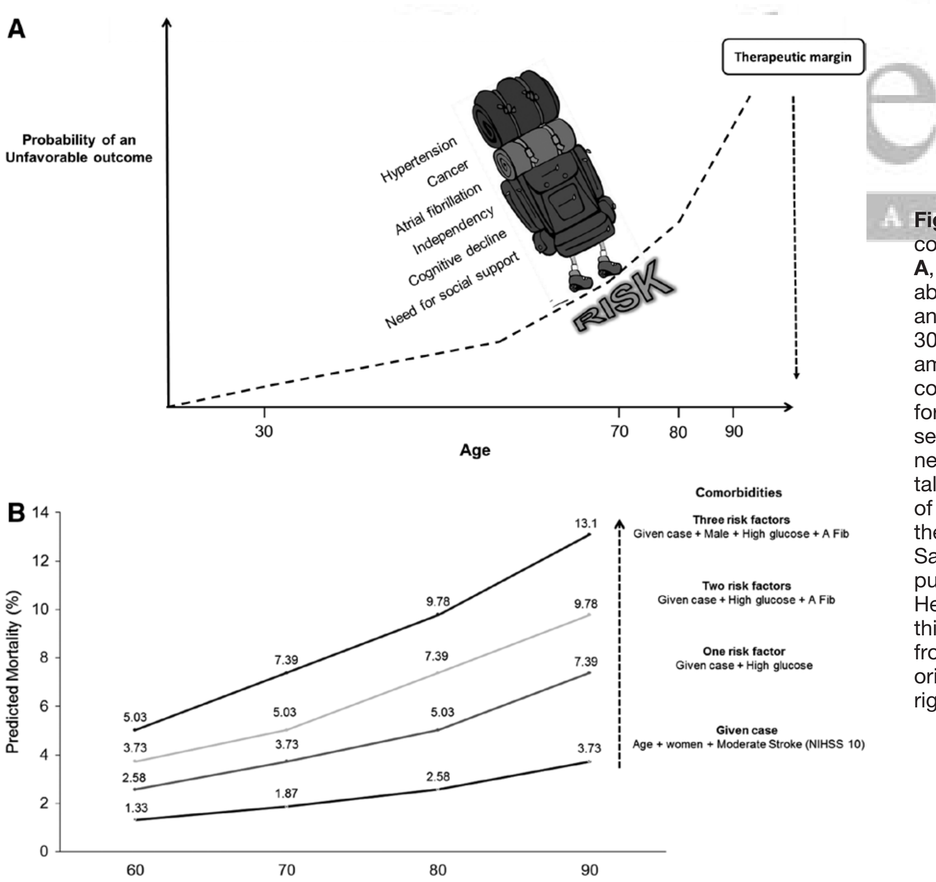

Figure 2. Amplifying effect of age and comorbid conditions on stroke outcomes. **A**, A scheme of the lifetime risk and probability of an unfavorable outcome after an acute ischemic stroke. **B**, Death at 30 days as estimated by the iScore. The amplifying effect of age and comorbid conditions on stroke outcomes. Note, for patients with a given age and stroke severity, additional comorbidities exponentially increase the risk of 30-day mortality. NIHSS indicates National Institutes of Health Stroke Scale. Data derived from the Ontario Stroke Registry. Adapted from Saposnik et al[4] with permission of the publisher. Copyright © 2011, American Heart Association, Inc. Authorization for this adaptation has been obtained both from the owner of the copyright in the original work and from the owner of copyright in the translation or adaptation.

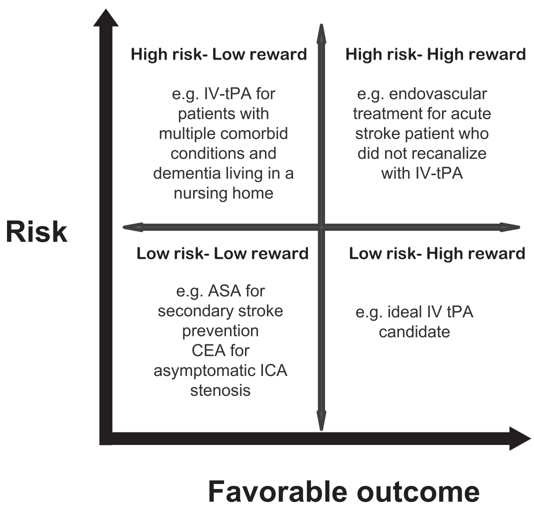

Figure 3. Risk aversion and tolerance. ASA indicates aspirin; CEA, carotid endarterectomy; ICA, internal carotid artery; IV, intravenous; and tPA, tissue-type plasminogen activator.

remain hidden until the end of the game (imperfect information). Poker games vary in the number of cards dealt, the number of shared or community cards, and the number of cards that remain hidden. In most modern poker games, the first round of betting begins with one of the players making a bet without knowing either the opponent's or the community cards.[19] The action then proceeds clockwise as each player in turn must match the maximum previous bet or fold, losing the amount bet to this point and all further interest in the hand. A player who matches a bet may also raise or increase the bet. This is based on the player's assessment of the chances of winning a hand with limited available information (his/her card and later on the progressive unblinding of the community cards).[19] If a player thinks that he/she has a low probability of winning the hand, then he/she can fold and avoid wasting money. Although the outcome of any particular hand significantly involves chance, the long-run expectations of the players are determined by their actions chosen on the basis of psychology, financial status, and the game theory (note: In 1947, John von Neumann and Oskar Morgenstern showed that an individual's preferences can be represented on a scale, and the individual will choose actions that maximize the expected benefit called usefulness).

A general rule among professional poker players is the sooner a player folds (prompt decision), the lower the chance of losing money (ie, having a bad outcome). This requires some training and the ability of poker players to anticipate an unavoidable outcome. Although there are multiple psychological factors involved in the decision to play a hand or fold, there are mathematical estimations of the probability winning a hand based on the player's pairs of cards and position on the table (http://www.cardschat.com/odds-for-dummies.php; accessed February 23, 2014).[19,20] Figure 4 illustrates the stratified probability of winning versus unplayable hand (dark gray=high risk of losing) for each pair of cards.

Interestingly, medical decisions share similarities with decisions made by (professional) poker players. For example, medical information is imperfect because clinicians in the emergency room may not be fully aware of all existing comorbidities, patients' preferences, or advanced directives (as poker players make decisions without knowing the opponent or community cards). Both poker players and clinicians have tools available to assist them making a rational and informed decision. For example, although poker players use risk stratification tables to assess the chance of winning a hand, clinicians have several risk scores (eg, ischemic stroke risk score [iSCORE], Stroke Prognostication using Age and NIHSS [SPAN-100], Preadmission comorbidities, Level of consciousness, Age, Neurologic focal deficit [PLAN], Totaled Health Risks in Vascular Events [THRIVE], Hemorrhage After Thrombolysis [HAT], dense cerebral artery sign, prestroke modified Rankin scale, age, glucose level at baseline,

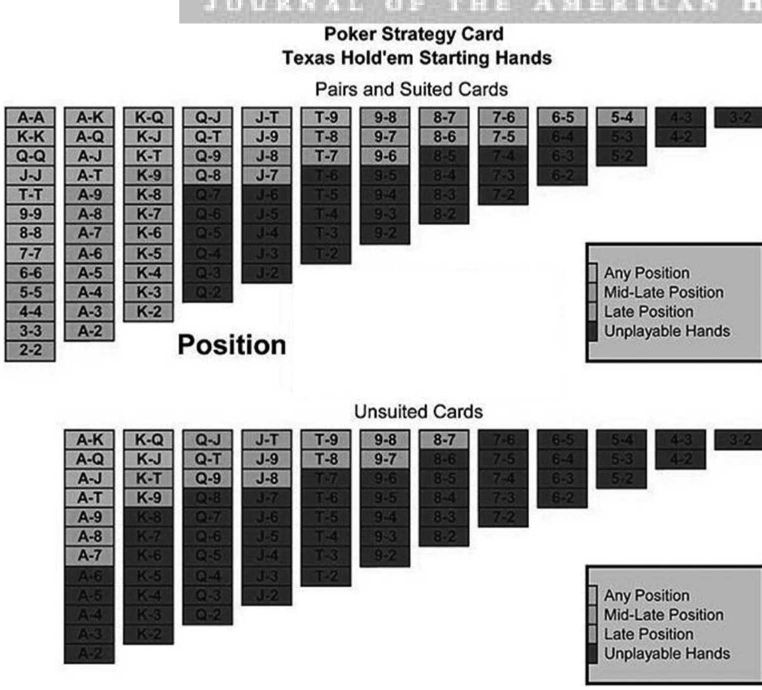

Figure 4. Poker strategy: probability of winning stratified by cards and position on the table. Reprinted from http://www.toponlinepoker.net/strategy/cards/ with permission of the publisher. Copyright © 2014, TopOnlinePoker.net. Accessed March 12, 2014. This tool is free to use and download. Further details are on the Web site.

onset-to-treatment time, and baseline NIHSS [DRAGON]) available to apply to a particular patient to estimate the potential outcome with or without giving either thrombolytic or endovascular therapy. There is a fine balance between risk aversion and risk tolerance. Risk aversion is the point at which people would not like/tolerate the possibility of a bad outcome. Contrarily, risk tolerance is the extent to which a patient chooses to risk experiencing a less favorable outcome in the pursuit of a more favorable outcome or reward.[13,21]

Certainly, poker players may decide to continue betting (higher risk tolerance) while having a lower chance of winning. Similarly, clinicians may decide to go ahead with more aggressive interventions (eg, administering intravenous tPA or endovascular therapy) even when the risk may be high and the estimated benefit is low.[22] However, this could represent a rational decision based on patients' preferences and family guidance.

Finally, another consideration relates to the existing financial incentives in the health system for stroke care. For example, physicians' decisions may be influenced by patient insurance status and hospital reimbursements. Readers may wonder how many less US physicians and hospitals would consider endovascular therapy if there were no reimbursement.

Do Clinicians Really Need Risk Scores to Make More Accurate and Rational Decisions?

A study of neurologists and emergency physicians revealed that only 11% (95% confidence interval, 0%–22%) could correctly predict the benefit of thrombolysis and about one third were able to estimate the risk of symptomatic and fatal intracerebral hemorrhage correctly.[23] It is not surprising that a recent systematic review concluded that computerized clinical decision support systems improve clinician performance.[24]

Previous studies[25–27] suggest that the use of a validated clinical risk score may improve clinician's performance and assist in providing more accurate prognostic information when counseling patients with stroke and their families. For example, The Clinician Judgment Versus Risk Score to Predict Stroke Outcomes (JURaSSiC) study assigned 111 clinicians with expertise in acute stroke care to predict the probability of outcomes of 5 ischemic stroke case scenarios.[28] Cases (n=1415) were selected as being representative of the 10 most common clinical presentations from a pool of ≥12 000 patients with stroke admitted to 12 stroke centers. The primary outcome was prediction of death or disability (modified Rankin Scale, ≥3) at discharge within the 95% confidence interval of observed outcomes. Clinicians made 1661 predictions with overall accuracy of 16.9% for death or disability at discharge, 46.9% for 30-day mortality, and 33.1% for death or institutionalization at discharge.[28] In contrast, 90% of the iScore-based estimates were within the 95% confidence interval of observed outcomes. Less than 50% of clinicians were able to predict the probability of the primary outcome in any of the 5 rated cases accurately, and <1% provided an accurate prediction in 4 of the 5 cases (none accurately predicted all 5 cases). In summary, clinicians with expertise in stroke performed poorly when compared with a validated tool in predicting the outcomes of patients with an acute ischemic stroke. The authors concluded that the use of the risk stroke outcome tool (ie, iScore) may assist clinicians to estimate stroke outcomes accurately, thereby potentially resulting in better decisions.[28]

Self-Assessment and Confidence in Decision Making: Does It Improve Clinical Outcomes?

The cognitive processes involved in clinical reasoning for prognostication are complex.[1,2] Some studies suggest that clinicians tend to overestimate the probability of a good outcome. For example, in the JURaSSiC study, clinicians' higher level of confidence was not associated with better outcome estimations.[28] Similarly, in the Swiss Hypertension and Risk Factor Program (SHARP) study, general practitioners and specialists (n=1040) thought that 65% and 69% of their patients had blood pressure under control. When the investigators measured the blood pressure of their patients (n=20 956), only 30% to 35% met the recommended targets.[29] Together, these examples illustrate that inaccuracies in clinician's estimations may be because of (1) overemphasis on positive findings or minimization of pertinent negative information and (2) disregarding the variability of biological events.[1,27]

How Many Factors Can Clinicians Simultaneously Judge When Making Decisions?

Heuristic is a Greek term that refers to experience-based techniques for problem solving that help identify a solution when exhaustive search is impractical. Judgment errors are often ascribed to limitations in our cognitive capacities to deal with imperfect information and the human tendency to adopt short cuts in reasoning.[2] Heuristic methods are used to speed up the process of finding a satisfactory solution using cognitive shortcuts when encountering difficult scenarios with imperfect information.

Anchoring and adjustment describe a common human tendency to rely too heavily on the first piece of information offered (the anchor) when making decisions.[13,30] For example, in a study, children were told to estimate the number of jellybeans in a jar, and groups of children were given either a high- or low-base number (anchor). Children estimated the number of jellybeans to be closer to the anchor number that they were given. Similarly, clinicians may have an anchor based on preliminary medical information that influences a subsequent decision. For example, clinicians may outweigh the negative effect of arrival from a nursing home or known dementia on stroke, thus being less likely to administer tPA to those patients even in the absence of contraindications. A recent study, including 70 stroke neurologists, confirmed this hypothesis.[31]

There is also a mental shortcut that occurs when people make judgments about the probability of events using examples that come to mind.[32,33] Similarly, clinicians may remember the outcomes of most recent patients and experiences that are related to a few and simple pieces of information (eg, age and stroke severity) that unconsciously affect their next decision.

In the JURaSSiC study, clinicians were more likely to be accurate when age, stroke severity, and stroke subtype all either worsened or improved the outcome.[28] Contrarily, clinicians were inaccurate when some of these variables affected the outcomes in opposite directions (eg, young individual with a severe stroke and elderly with a mild stroke). Together, this information suggests that clinicians usually use shortcuts when making decisions based on small, but relevant pieces of information that influence outcomes in the same direction. These shortcuts are usually based on pattern recognition (eg, patients with low or high probability of achieving a good outcome), whereas intermediary cases need systematic generation and testing of hypotheses.[1,27,30,32,33]

Cultural Organization: Social Influence in Decisions Making

On August 6, 1997, flight 801 from Korean Air departed from Seoul with destination to Guam. It was a foggy and rainy night, the crew was probably tired because the flight was supposed to reach the destination after midnight and the glideslope (instrument landing system) was not working properly. Miserably, the Boeing 747-300 crashed on Nimitz Hill in the center of Guam at 1:42 am.[34]

It was mentioned that the pilot was trying to do a visual landing (common procedure under regular circumstances), despite someone in the cockpit saying that the airport is not in sight. Neither the copilot nor the flight engineer spoke out boldly, as trained, to alert the captain or even urge breaking off the landing.[34] The crew did not know where they were or their altitude. Just seconds before the crash at 1:42 am, the last words heard were go around meaning pull up and try another approach. Shortly after, the mechanical voice counted down to 20 ft followed by the sound of the effect. The captain, first officer, a flight engineer, 14 flight attendants, and 237 passengers died. There were 26 survivors. The incident was attributed to a human error. However, the National Transportation Safety Board team concluded that the first officer and flight engineer failed to monitor and challenge the captain's performance properly, which was causal to the accident (http://ns.gov.gu/guam/indexmain.html).[34]

Cultural organization is the behavior that individuals in a society adopt based on values, visions, norms, working language, beliefs, and habits. In other words, under special circumstances, fear of challenging authority contributed to a horrible outcome. Potential explanations for such behavior may be rooted in cultural teachings about respect for authority that begin in childhood.[34] Interestingly, the extensive and formal aviation training received during their adulthood did not overcome the education received at childhood. Similar situations may also occur in acute stroke care if we manage patients or make decisions in isolation or discourage members of the team to challenge the staff by asking provocative questions.

Applying Bayesian Theory and Visual Aids in the Decision Making of Acute Stroke Therapy

In the previous sections, we illustrated the complexities of the decision-making process. We also showed that clinicians (even when experienced) may not provide accurate outcome estimations (or are inconsistent), which may lead to undesirable decisions.

However, the use of well-known and validated tools improves clinicians' estimations. For example, in a study, including patients with subarachnoid hemorrhage, clinician's accuracy was ≥80% when scales (eg, the Hunt-Hess scale and Glasgow Coma Scale on admission) and need for mechanical ventilation were added to clinical judgment.[25] Similar improvement was observed in the Study to Understand Prognoses and Preferences for Outcomes and Risks of Treatments (SUPPORT) using the Acute Physiology and Chronic Health Evaluation (APACHE) score in critically ill patients.[26]

Bayesian probability theory assigns a theoretical quantity for the purpose of representing a state of knowledge. This starting point is called the pretest or previous probability. When more data become available, it is incorporated to estimate a new probability of an expected outcome, which then becomes the next previous probability.[35,36] As such, the acquisition of novel information (eg, cardiac failure and atrial fibrillation) during the acute neurological assessment of patients with stroke serves as a new starting point to estimate the probability of a favorable outcome. Clinicians usually use previous experiences and their perceptions when estimating risk. The anterior cingulate cortex, orbitofrontal cortex, and the overlapping ventromedial prefrontal cortex are brain regions involved in decision-making processes.[37] A recent study found that uncertainty about perceptual evidence is located in the visuomotor areas, whereas uncertainty about previous beliefs is encoded in the insula, orbitofrontal cortex, putamen, and amygdala. This information suggests the uncertainty map in humans resides in neural pathways that rely on current or previous knowledge.[38] Bayesian theory suggests that the incorporation of new pieces of information affects the estimated probability of an event. The use of risk scores in conjunction with visual aid tools (Figure II in the online-only Data Supplement) may also help identify how close or far a patient is from achieving a favorable outcome.[39] For example, for every 100 patients treated within 3 hours, 32 will have a better and 3 will have a worse final global disability outcome as a result of thrombolytic therapy.[39]

Clinicians may also have difficulties to estimate outcomes between similar patients (eg, 75 years with National Institutes of Health Stroke Scale, 14), but with different comorbid conditions (eg, cardiac or renal failure and atrial fibrillation).[28] This concept is even more relevant when considering patients with a marginal/low probability of a favorable outcome and a high risk of symptomatic intracerebral hemorrhage. Some risk prediction tools may help identify patients who have a higher chance of achieving a benefit from thrombolytic or endovascular therapy, as well as those who are at high risk of developing complications or a poor outcome (eg, symptomatic intracerebral hemorrhage and death). For example, the iScore had an interaction with intravenous tPA, meaning that patients with a score <130 had the highest likelihood of achieving a favorable outcome with tPA. Contrarily, patients with an iScore >200 did not seem to benefit from thrombolysis (www.sorcan.ca/iscore) in the studied cohort.[40,41] The Thrive score, applied to patients undergoing endovascular treatment in the Thrombectomy Revascularization of Large Vessel Occlusions (TREVO)-2 trial, also estimated outcome well for patients in the lower (0–2) categories (www.thrivescore.org) although there was no interaction of the score with treatment.[18]

The combination of a visual aid and the application of Bayesian methods (eg, use of stroke risk outcome scores) is an effective strategy when counseling patients with stroke and their families. Moreover, it may help clinicians provide recommendations based on more accurate estimations.

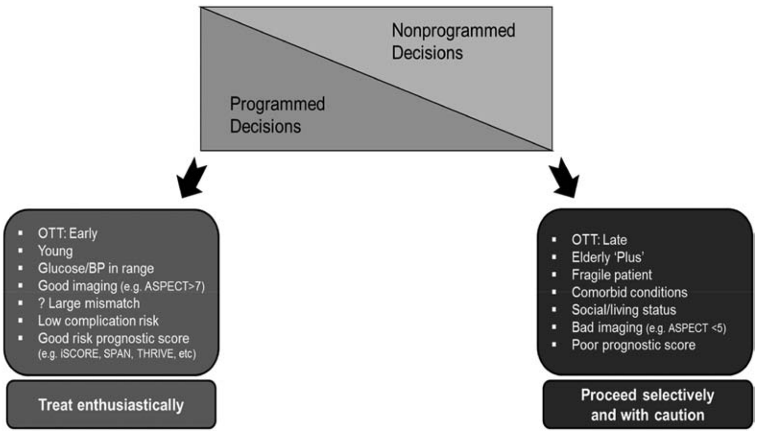

Figure 5. Decision making: programmed and nonprogrammed decisions. Created by Dr Saposnik, modified from a lecture given by Dr Andrew Demchuk. Elderly Plus refers to older patients (usually ≥80 years) with extensive comorbid conditions know to affect stroke outcomes directly. ASPECT indicates Alberta Stroke Program Early Computed Tomographic score; BP, blood pressure; and OTT, onset-to-treatment.

Succumbing to the Temptation: Low-Ball Technique

Low ball is a marketing and sales tactic that involves quoting a low price initially followed by higher prices. Many customers accept a transaction that is initially perceived as a low cost deal, and then are inclined to accept the subsequent higher price because they have already decided to purchase an item or a service. The classic example is the 50% off or low entry price deals offered by different companies (eg, communications, internet providers, and car dealers) that last for a few months. Then, customers later pay higher (the regular) prices, usually hidden, misread, or dismissed at the time of the initial offer. Another example is the strategy used by online poker Web sites. Players usually start with small bets, being rewarded by winning.[19,42] This acts as a positive reinforcement for the dopaminergic brain reward system and lead to participants increasing bet amounts. The result is that players are incentivized to play more by an initial small reward but end up losing larger amounts of money in subsequent bets.[43–45]

How do these strategies affect clinicians? We are all exposed to low-ball and other marketing and sales strategies. In clinical care, the first piece of information may seem to be tempting, meaning to treat patients or use more aggressive approaches. A careful analysis (thinking slow or using the system 2)[13] of all relevant pieces of information may provide a more realistic assessment and better final decision. For example, a clinician may be tempted to administer intravenous tPA to a 79-year-old man with a National Institutes of Health Stroke Scale of 18, Alberta Stroke Program Early Computed Tomographic score of 7, and no contraindications. However, a thorough assessment of subsequent relevant factors (eg, patient was living in a nursing home, history of severe dementia requiring assistance for all activities of daily living, and poor collateral flow) may affect the final decision (Figure 5). At the individual level, clinicians need to develop a process for making strategic choices and deliver high quality of care. Despite the major technological advances in diagnostic and therapeutic procedures in cerebrovascular disease, our healthcare systems have stumbled in providing equal and consistent high-quality access to specialized stroke care.

Multiple Barriers to Prevent Medical Errors: the Swiss Cheese Model

The Swiss Cheese approach to error prevention defends against errors by having a series of barriers, represented as slices of cheese. The holes in the slices represent weaknesses in individual parts of the system and are continually varying in size and position across the slices.[46] Failures in the system occur when a hole in each slice momentarily aligns, allowing a trajectory of accident opportunity, so that a hazard passes through holes in all of the slices, leading to a failure. In other words, a major system failure cannot be explained by a single hole but rather by a combination of holes in the system.[46] For example, the lack of deep venous thrombosis prophylaxis for a patient with an acute ischemic stroke with a hemiplegia can be seen as a system rather than an individual failure. A physician may forget to write the indication, but there should be other barriers in the system to protect patients from not receiving this appropriate treatment (eg, standardized orders and nurses checking usual/evidence-based recommendations for stroke patients). In other words, safety mechanisms should be in place to prevent an individual error from resulting in dramatic consequences for our patients. Errors in systems may occur at different times and at several levels but less likely to occur simultaneously.

Future Directions

As clinicians, we are exposed to the uncertainties in the benefits of therapies in complex clinical situations. The assessments of risks, potential benefits, and patient preferences are key elements when counseling patients or making decisions. As described above, there are some tools available to help us making prompt and rational recommendations. For some, this is an unconscious process. For others, it may require awareness of our own biases and potential heuristic errors and may improve with the use of visual aids and risk scores to master the art of decision making. Moreover, as most of risk scores have been created from retrospective studies, a prospective validation in a randomized trial where patients are treated/not treated using or not using results of the predictive models might be warranted. In the era of patient-centered outcomes, we expect a smooth integration of technology and active patient participation in decision making of treatments. Paraphrasing Napoleon Bonaparte (1769–1821), "nothing is more difficult, and therefore more precious, than to be able to decide."

Acknowledgments

We declare that we have participated in the conception, design, analysis, interpretation of the results, drafting the article, and made critical revisions of the article.

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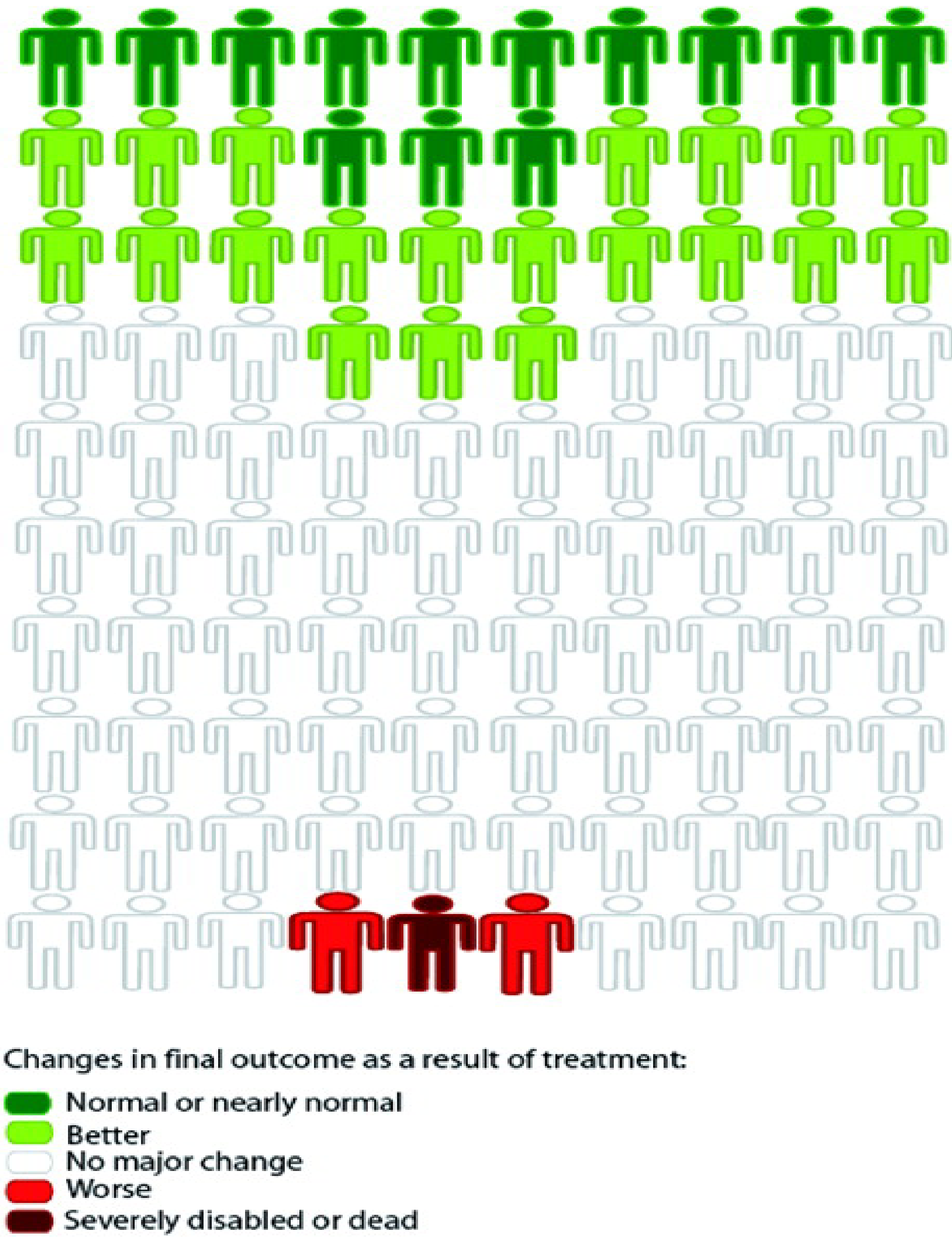
Key Words: decision making ■ economics ■ medicine ■ risk ■ stroke ■ thrombolytic therapy ■ uncertainty

Supplemental Material

Figure I. The 6 C's of decision making

❶	Construct	what needs to be decide
❷	Compile	list of requirements
❸	Collect	information on alternatives
❹	Compare	alternatives (that meet the requirements)
❺	Consider	potential risks
❻	Commit	to a decision

Figure II. Visual Aid tool: decision matrix figure illustrating the benefits and risks of intravenous TPA in the <3-hour window based on data from the 2 NINDS-TPA trials.



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