Visual Preoperative Risk Depiction Tools for Shared Decision-making: A Pilot Study from the Surgeon’s Perspective

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Background: Shared decision-making (SDM) and effective risk communication improve patient satisfaction, adherence to treatment, and understanding of perioperative care pathways. Available risk calculators are less relevant for low-risk operations. The aim of this pilot study was to develop graphical risk visualization tools to enhance surgical SDM discussions preoperatively.

Methods: Complications for reduction mammoplasty and skin grafting in a burns setting were sourced from the American College of Surgeons National Surgical Quality Improvement Program Surgical Risk Calculator, the American Society of Plastic Surgeons website, peer-reviewed literature, and available clinical data. Pre- and postoperative patient satisfaction data were collected from the published literature on Breast-Q patient-reported outcomes for reduction mammoplasty. Everyday risk comparisons were collected from a general online database search. Three distinct risk depiction tools (spiral, tile, and scatter plot) were developed in the Microsoft Office Suite. Anonymous REDCap surveys were sent to healthcare practitioners for feedback.

Results: Twenty-six survey results were collected. Twenty-four respondents (92%) agreed these graphics would be useful for SDM discussions. Nineteen respondents (73%) either agreed or strongly agreed that these graphics depicted risk in a meaningful way. Fifteen respondents (58%) indicated they would use these graphics in daily practice. The majority of respondents preferred the spiral design (58%). Areas for improvement included design simplification and written explanations to accompany graphics. Feedback from the survey was incorporated into the spiral design.

Conclusions: Risk visualization tools meaningfully depict surgical risks to improve communication in SDM. This study proposes a tool that can be adapted for many surgical procedures. (Plast Reconstr Surg Glob Open 2022;10:e4690; doi: 10.1097/GOX.0000000000004690; Published online 29 November 2022.)

INTRODUCTION

The medical profession has shifted away from paternalistic doctor-patient relationships to shared decision-making (SDM).¹ At its core, SDM is the marriage of patient preferences and values with evidence-based clinical options, allowing patients and providers to make decisions suitable for the clinical problems at hand.² SDM is associated with greater patient satisfaction, improved adherence to treatment, increased understanding of perioperative care pathways, and less decisional conflict and regret.³,⁴ A fundamental premise of SDM is effective risk communication.³ This was highlighted by the Montgomery judgment in 1999: “the doctor is...under a duty to take reasonable care to ensure that the patient is aware of any material risks involved in any recommended treatment...”⁵ However, psychology research over the past half century has highlighted the challenges of communicating risks,
including undue influence of affect and availability heuristics that lead to overestimation and/or underestimation of risk. This has been dramatically exemplified in recent times by public and government responses to the COVID-19 global pandemic that exacerbated the socioeconomic determinants of health in communities around the globe while attempting to curb the spread of disease and its associated morbidity and mortality. The public was forced to conceptualize risk of COVID-19 exposure, transmission, and associated mortality from a public health perspective. As demonstrated by press coverage, efforts to “flatten the curve” were limited by public cooperation, in part due to incomplete understanding of these risks.7–10

In the context of surgery, SDM may translate to more moderate use of surgery and reduced healthcare costs.11 However, surgical complications warrant better risk communication strategies.12–14 Clinicians tend to overestimate the risk of mortality associated with a condition and underestimate the risk of complications and side effects associated with treatment.15–17 On the contrary, the general public tends to exaggerate small risks and underweight more probable risks.18,19 Effective risk communication needs to bridge differences in risk perception between experts and lay people, addressing judgement heuristics to facilitate decision-making. It also needs to convey complex, multidimensional data (ie, type of risk, likelihood of risk, severity of risk, and comparator risks) in a manner that is relatively simple to understand and does not rely exclusively on verbal expressions of risk.

There currently is a lack of consensus about the most effective method for communicating surgical risk.20 The “micromort” framework, introduced in 1989 by Howard, has been used to index and communicate health risks in some surgical settings.21–23 A micromort is defined as a one in a million risk of acute death associated with an activity,24 allowing for a diverse range of activities to be compared in terms of their “riskiness.” For example, skydiving and general anesthetic carry approximately the same acute risk of death (10 micromorts). There are, however, important limitations that must be kept in mind. First, it is an index of acute death and does not represent long-term mortality associated with a medical decision. Second, it does not reflect morbidity associated with a procedure or outcomes such as disability or quality of life. Third, as highlighted by Keage and Loetscher,25 participants tend to misjudge the magnitude of risk depicted in a numerical format, considerably underestimating high-risk activities. This is further compounded by the non-linear mental representation of numbers at very high and very low values,25 making it difficult to comprehend and compare probabilities spanning orders of magnitude. Finally, micromorts are average measures and do not reflect individual circumstances.25

Over time, other surgical risk prediction tools, including the American College of Surgeons National Service Quality Improvement Project (ACS-NSQIP) calculator, have been developed to give more nuanced estimates of risk. This risk prediction tool enumerates the 30-day risk of various postoperative complications, not just mortality, for a diverse range of operations and allows more individualized outcomes to be generated based on a patient’s age and comorbidities. It is particularly useful for elderly, multimorbid patients and less relevant for otherwise healthy individuals undergoing minor procedures. However, akin to the micromort framework, the ACS-NSQIP poorly represents patient-reported outcome measures and quality of life scores, which are becoming increasingly important for SDM.

There is thus a need for appropriate risk communication tools that are suitable for a broad range of procedures and encompass relevant information for preoperative SDM. The aim of this project was to develop a graphical risk visualization tool that (1) enhances SDM in the preoperative setting, (2) is applicable to any surgical intervention, and (3) has the potential for individualization based on patient factors and/or local institutional practices. This pilot study collects feedback from healthcare practitioners for further refinement of the proposed designs before introduction to patient cohorts. The eventual goal of this project is to finalize an optimized risk graphic for rigorous clinical testing with input from patients and providers alike.

**METHODS**

A low-risk plastic surgery procedure—reduction mammoplasty—was chosen as an exemplar to develop our risk visualization graphic. Three designs were created to evaluate the efficacy of different visual layouts. The ACS-NSQIP surgical risk calculator20 was used to generate risk percentages for reduction mammoplasty in an average breast reduction patient, which we defined as a female patient with mild systemic disease (hypertension, diabetes) and BMI within the normal range. Procedure-specific complications for reduction mammoplasty were aggregated from the American Society of Plastic Surgeons website.27 For complications not included in the risk calculator, rates were extracted from peer-reviewed literature for reduction mammoplasty.29,30 Pre- and postoperative patient satisfaction data were collected from the published literature on Breast-Q outcomes for reduction mammoplasty.31,32 The data depicted are the representative of generalized risks and may not reflect actual risks at individual centers for individual patients. Everyday risk comparisons were compiled from reputable sources including the Center for Disease Control, National Health Statistics Report, United States Department of Justice, Australian Institute of Health and Welfare, and the American College of Obstetricians and Gynecologists database.
Figures were constructed using the Microsoft Office Suite. For all graphics, operative risks are depicted in shades of red, everyday risk comparisons in gray, and benefits in green. Color intensity correlates with the severity of risk and is a subjective, composite interpretation of the following factors: irreparable consequence, need for reoperation, Clavien-Dindo classification, and Accordion classification. The size of the graphic element (wedge, tile, or circle) corresponds to the magnitude of the risk. Everyday risk items are interspersed between procedure-specific risks to put the surgical risk into perspective.

REDCap surveys (Table 1) were sent broadly to healthcare professionals via email listservs, social media groups, and active clinical teams to gather feedback pertaining to the usefulness and utility of each graphic as well responders’ preference for the graphic type. The survey was open to all individuals with the active REDCap link and responses were collected anonymously. The final choice of graphic was determined based on preferences expressed in survey responses. Design refinement and modifications were made based on the feedback received and applied to another low-risk plastic surgery procedure—skin grafting for burns patients.

Table 1. REDCap Survey Used to Ascertain the Usefulness and Useability of the Risk Depiction Graphics Used in This Study

| Question | Options                              |
|----------|--------------------------------------|
| 1. Which design would you be most likely to use? | Spiral, Tile, Scatter plot |
| 2. The information on the graphic is easy to understand | Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree |
| 3. These graphics depict risk in a meaningful way | Disagree, Neither agree nor disagree, Agree, Strongly agree |
| 4. These graphics would be useful for shared decision-making discussions | Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree |
| 5. I would use these graphics in my daily practice | Difficult to understand, No additional benefit, Limited time, Poor aesthetic, Other |
| 6. I would not use these graphics because | Spiral, Tile, Scatter plot |
| 7. How can we improve each of the designs? | Spiral, Tile, Scatter plot |

RESULTS

Graphics
We created three unique graphics to illustrate operative risk (Figs. 1–3). In the spiral design (Fig. 1), wedges of varying sizes illustrate the risks and benefits that are placed on the circumference of an imaginary circle. Inner concentric circles correspond to certain probabilities of risk/benefit for ease of calibration. Figure 2 depicts the tile design. In this graphic, the size of the red or gray risk tiles corresponds to the magnitude of the risk. Given the large proportion of patients benefiting from the procedure, the size of the green tiles representing benefits could not be drawn proportional to the benefit they represent. The final graphic depicts risks using a scatter plot (Fig. 3). Here, the size of the circles and their placement along the horizontal axis provide two visual clues as to the magnitude of risk they represent. In addition to the red or gray color shades that highlight severity of risks, placement of the circles along the vertical axis provides another visual clue to the severity of the risk. In this graphic, the benefits of a procedure are depicted by the rectangular green blocks on the background of the image. Their size and placement along the horizontal axis gives visual clues as to their magnitude.

Survey
Twenty-six individuals responded to the anonymous survey conducted at Brigham and Women’s Hospital in Boston, Massachusetts, and Royal Perth Hospital in Perth, Western Australia. All respondents (n = 26, 100%) identified as health care providers. The majority of respondents (n = 19, 73%) agreed or strongly agreed that these graphics depicted the risk in a meaningful way and nearly all (n = 24, 92%) agreed that the graphics would be useful for SDM discussions. Fifteen respondents (58%) agreed or strongly agreed that they would use these graphics in their daily practice, seven (27%) neither agreed nor disagreed that they would use these graphics in their daily practice, and four (15%) disagreed or strongly disagreed that they would use the graphics in their daily practice.
The majority of the respondents preferred the spiral design (n = 15, 58%), followed by the scatter plot design (n = 9, 35%). Eleven participants (42%) agreed or strongly agreed that the information on the graphic was easy to understand, six (23%) neither agreed nor disagreed that the information was easy to understand, and nine (34.6%) disagreed or strongly disagreed that the information was easy to understand. With regards to reasons for not using the graphics, eight (42%) participants mentioned that the graphics were difficult to understand, one participant (5%) felt the graphics provided no additional benefit, one (5%) believed it would take up additional time, one (5%) mentioned poor aesthetic, whereas nine (47%) gave other reasons. Consistent with the reasons for not using the graphics, areas for improvement included design simplification and some written explanation to accompany the graphic. The most common reason limiting the use of the graphics in daily practice was difficulty in understanding them. Contrary to what might be anticipated, limited time did not appear to be a major barrier. Further changes were made to the spiral graphic based on the feedback received to create the final visual tool (Fig. 4). It is possible that the final graphic, which is simpler in design and easier to comprehend after incorporating feedback from respondents, may remove further barriers for its implementation in everyday practice, which we will assess in future studies and cohort comparisons.

**DISCUSSION**

We present a pilot study developing a novel visual tool to depict the risk in surgery. Our final design places surgical risks in the context of comparable everyday risks and evidence-based benefits of the procedure. This allows for a more nuanced and balanced approach to preoperative counseling and informed decision-making. The strength of this tool stems from its creativity, ability to be individualized to patient and local practice data, incorporation of patient-reported outcome measures, and ability to convey multidimensional data (ie, type of risk, magnitude of risk, severity of risk, and comparative risk) using simple visual elements such as size and color. The visual depiction of numerical data addresses judgment and availability heuristics that can impede accurate perception of risk. Reduction mammoplasty and skin grafting in the burns setting, low-risk plastic surgery procedures, were selected to illustrate the use of this tool as part of the SDM process in plastic surgery.

Effective communication of risk has become increasingly important in medicine and surgery. Broadly speaking, three formats of risk communication exist: verbal, numerical, and graphical. Verbal risk communication refers to the use of descriptive labels such as “high risk” and “low risk” or “common” and “rare.” Such descriptors leave considerable room for interpretation, ambiguity in definition, and increase the likelihood of misinterpretation. These concerns can be addressed, at least partly, by using numerical tools to convey risk. Although more accurate, numerical formats rely on patients having adequate health literacy to interpret data presented to them and are subject to various cognitive biases in the context of probabilities spanning orders of magnitude. For instance, only 25% of the general population...
could correctly identify one in 1000 as being equivalent to 0.1%. Even among highly educated people numeracy appears to be low, highlighting the limitations of relying exclusively on numerical formats for risk communication. A visual adjunct to numerical descriptions of risk, as presented in the present study, is therefore important to facilitate accurate risk communication.

From our pilot study, most respondents to our survey agreed that the graphics designed by our team depicted the risk in meaningful ways, with nearly all respondents agreeing that these visuals would be useful for SDM discussions. This is in keeping with existing literature suggesting that SDM is valued by both patients and clinicians because it improves the quality of decisions while lessening conflict in the decision-making process. Patient dissatisfaction and complaints often arise from differences in understanding risks and benefits, with up to 25% of complaints focused on issues surrounding treatment options and alternatives. The quality of the decision-making process and interactions between surgeons and patients, rather than the end decision per se, appear to be key in improving patient satisfaction and outcomes. Our survey revealed that most practitioners would use a version of our novel graphic in their daily practice. The risk visualization...
Fig. 4. Spiral design updated to incorporate respondent feedback. Figures depict risks associated with (A) reduction mammoplasty, everyday risk comparisons, and BREAST-Q outcomes, and (B) burn reconstruction. Operative risks are depicted in shades of red, everyday risk comparisons in gray, and benefits in green. Color intensity correlates with the severity of risk. The size of the wedge corresponds to the magnitude of the risk.
graphics are tools that enhance preoperative decision-making by depicting key risks alongside anticipated benefits and relevant everyday risks. We hope that such a tool will facilitate open, two-way, objective discussion before surgery, informing patients’ decision-making process. Furthermore, our risk visualization tool allows patients to take home information on surgical risks and deliberate decisions regarding their health in their own time. By having concrete information about the procedure as opposed to vague phrases like “low risk,” “a possibility,” or “minor complications,” patients can find certainty in their decisions and more readily involve friends and family in the decision-making process.

Although unique, this project has a number of limitations that must be acknowledged. First, the graphical designs are examples of how preoperative risk may be conveyed to patients. There may be other formats that achieve the same goal and are not explored in the present study. We sought to generate three graphics that we believed were suitable and chose one based on survey responses. Second, the REDCap survey was conducted in a limited convenience sample of participants, some of whom were colleagues known to the authors. Although anonymous, familiarity of respondents with the study authors could bias the results towards more favorable outcomes. Nonetheless, a diverse group of practitioners was surveyed as the survey was sent broadly to physician groups and active clinical teams, and survey responses were collected without restrictions. Many respondents did provide extensive, written constructive feedback suggesting critical assessment of the proposed designs despite any potential bias. A randomized trial at a number of different surgical clinics would better elucidate the utility and usability of this tool in a real-world setting. We plan to seek input from patient populations in a future study as our graphics are further refined, eventually progressing to a controlled cohort study. The intention of this initial study was to assess the utility of such tools from the clinician’s perspective for primary design development. Third, while all attempts were made to objectively assess the “severity” of complications, it was difficult to ascertain how individual patients view the severity of various complications. The severity scores reflect the authors’ judgment and are for illustrative purposes only.

In conclusion, graphical risk visualization tools meaningfully depict surgical risks and have the potential to improve SDM in surgery. We have developed a simple risk visualization tool that can be readily adopted by clinicians for their practice and patient population. Preliminary findings suggest that practitioners view this tool favorably and that it has the potential to improve communication of surgical risk in a clinical setting.
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