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Risk Prediction Tools for Estimating Surgical Difficulty and Perioperative and Postoperative Outcomes Including Morbidity for Major Urological Surgery: A Concept for the Future of Surgical Planning

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Abstract

Risk assessment plays a critical role in surgical decision-making and influences patient care, resource allocation, surgical planning, and postoperative outcomes. Accurate stratification facilitates better treatment selection and planning, and identification of teaching cases. Existing tools such as POSSUM and the Surgical Apgar Score are widely used but focus primarily on general surgery and often lack urology-specific considerations or integration of intraoperative factors. Urological surgery requires a dedicated tool that accounts for preoperative factors (eg, prostate size, tumour extent), intraoperative findings (eg, fibrosis, adhesions), and patient-specific complexities. We propose a comprehensive scoring system for risk and surgical difficulty that ranges from 0 (no risk) to 100 (procedure abandonment or death) covering five parameter categories: preoperative patient characteristics; intraoperative patient factors; preoperative organ-specific parameters; intraoperative organ-specific factors; and unexpected postoperative conditions. The aims of the proposed system are to improve surgical planning, enhance risk prediction, and identify suitable teaching cases. By incorporating surgeon-specific factors such as case volume and learning curves, the system stratifies procedures by difficulty and can facilitate comparisons between surgeons and hospitals. The system can also promote transparency in patient counselling and may improve the quality of patient consent. Once validated, the scoring system could be integrated into standard practice to improve surgical care, resource allocation, and research efforts. Despite challenges such as comprehensive data collection, this tool offers significant potential to enhance surgical outcomes and multidisciplinary decision-making.

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Patient summary: Risk assessment is essential in helping surgeons and anaesthetists to make better decisions before, during, and after surgery. The aim of our work is to create a tool that predicts potential risks and challenges during surgery and makes it easier to prepare for these challenges. This tool can improve management of resources and surgical planning, and may ensure smooth recovery after an operation. Finally, it could also help patients and their families to understand the potential risks involved, giving them clearer information about what to expect and making the process more transparent and reassuring.

Risk assessment is vital in surgical decision-making and influences patient care, resource allocation, surgical planning, and postoperative follow-up. Accurate risk stratification ensures appropriate treatment selection and better patient outcomes. While many risk indices exist, they have limitations and are often focused on preoperative patient characteristics and comorbidities. Tools such as the Surgical Apgar Score [1], Surgical Outcome Risk Tool [2], and the Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity (POSSUM) [3] are widely used in general surgery. Among these, POSSUM is comprehensive and includes operative findings, but it was not designed to guide surgical candidacy.

Urological surgery lacks a dedicated risk assessment tool. General indices such as the Charlson comorbidity index and American Society of Anesthesiologists (ASA) classification, although commonly used, have limited applicability owing to the absence of urology-specific considerations. Frailty indices, while increasing in popularity, are often restricted to specific populations. Existing tools also overlook intraoperative variables, which significantly impact outcomes. Nephrometry scores such as RENAL and PADUA assess imaging features but fail to account for intraoperative challenges [4,5].

The development of a urology-specific tool that integrates preoperative factors (eg, prostate size, tumour extent), intraoperative findings (eg, fibrosis, tumour growth), surgical approach, and patient-specific complexities could bridge this gaps and improve planning and outcomes. Therefore, we decided to develop a consensus-based index of risk and surgical difficulty that ranges from 0 (no risk/lowest difficulty) to 100 (death/procedure abandonment). While no procedure is risk-free, a scale from 0 to 100 offers a practical framework. Similar to the formula for the Comprehensive Complication Index (CCI) [6,7], variables can be included to allow for more precise discrimination of the severity and impact of preoperative and postoperative risk factors.

The goal is to create a prediction system for surgical difficulty and perioperative and intraoperative risk, and organ-specific scoring frameworks. These tools will aid in surgical planning, case selection, and identification of teaching suitability.

The primary objectives are:

1. To predict outcomes using both preoperative and intraoperative factors;
2. To predict outcomes using preoperative factors alone to optimise resources and identification of teaching cases; and
3. To establish surgical difficulty as a metric for comparing outcomes between surgeons and interventions.

Our proposed concept, generated by the representative steering committee (including four urologists from various specialties, two anaesthetists, and a methodologist), is a comprehensive scoring system that combines an organ-specific subscore for the target organ with preoperative and intraoperative considerations. The prediction tools will include five parameter categories:

1. Preoperative patient characteristics (eg, body mass index, ASA score, comorbidities, prior abdominal surgery).
2. Intraoperative patient factors (eg, bleeding tendency, adhesions).
3. Preoperative organ-specific parameters (e.g., tumour size/location, prior interventions).
4. Intraoperative organ-specific factors (e.g., fibrosis, extraprostatic tumour growth).
5. Unexpected postoperative conditions (eg, acute kidney injury).

We followed a rigorous multistep process for identification and selection of potential risk factors. First, we identified risk factors with a statistically significant association with complications following radical cystectomy and urinary diversion, radical prostatectomy, retroperitoneal lymph node dissection, or upper tract surgery (including partial and radical nephrectomy and nephroureterectomy). This was achieved via an extensive analysis of tertiary hospital databases. Second, we conducted a systematic literature review of complication-intervention events after major urological procedures to identify additional clinically relevant risk factors. The primary endpoints comprised complication-intervention events occurring within 1 yr postoperatively, with particular attention to 30-d and 90-d outcomes. Secondary endpoints included graded events according to the Clavien-Dindo classification, the CCI, and the modified Bern CCI. The steering committee used clinical expertise and consensus discussions to refine and define further potentially significant risk factors.

Surgical and anaesthetic complexity, influenced by case volume, experience, and learning curves, will also be

Table 1 – Proposed framework for calculation of scores to estimate surgical difficulty and intraoperative and postoperative risks[a]

Parameter	Score[b]		
	Surgeon		ANT
	SgD	RoC	RoC
Non–organ-specific factors			
Expected/known preoperative parameters			
Diabetes			
American Society of Anesthesiologists class			
Timing of surgery (morning, evening)			
Body mass index in kg/m^2			
Use of anticoagulant agents			
Elective vs emergency setting			
Previous non–organ-specific therapy (eg, radiation)			
Charlson comorbidity index			
Prior abdominal surgery + type (eg, bowel resection vs cholecystectomy)			
Prior diverticulitis episodes			
Nutrition status (eg, albumin, weight loss, cachexia)			
Age			
Sex			
Steroid use for chronic condition			
Smoking status			
Alcohol abuse			
Further parameters[c]			
Unexpected/unknown intraoperative parameters			
Intraoperative fluids administered in ml)			
Estimated blood loss in ml			
Duration of operation in min			
Electrocardiograph abnormalities			
Ventilation difficulties			
General overall tissue quality			
Ooziness/tissue vascularity			
Scarred tissue			
Adherent tissue			
Identifiable planes			
Vision			
Vessel injury			
Intraoperative blood transfusion			
Further parameters[c]			
Unexpected/unknown immediate postoperative parameters			
Acute kidney injury (eGFR decrease by 10 ml/min)	–		
Significant need for analgesia (opioids >50 µg)	–		
Organ-specific factors[d]			
Expected/known preoperative parameters			
Prostate size on MRI (eg, very small or very large)			–
Tumour size on MRI (maximal diameter in cm)			–
Number of preoperative biopsies			–
Number of biopsy cores taken			–
Type of biopsy (transrectal vs transperineal)			–
Gleason score (on biopsy)			–
Previous TURP/HoLEP			–
Previous simple prostatectomy (open/minimally invasive surgery)			–
cT stage (digital rectal examination/MRI)			–
Time between biopsy and surgery (eg, 1–3 wk, 3–6 wk, >6 wk)			–
Previous radiation (and dose regimen, eg LDR vs HDR) ± ADT			–
Inguinal hernia repair (laparoscopic vs open, with/without mesh)			–
Body mass index (obesity)			–
Further parameters[c]			–
Unexpected/unknown (intraoperative) parameters			
Narrow bony pelvis			–
Extensive intrapelvic fat tissue			–
Extensive prerectal fat tissue			–
Fibrosed tissue at NVBs (difficulty in applying Hem-o-lok/metal clips)			–
Locally advanced/infiltrative tumour (pT3b/4)			–
Large/flaccid bladder			–
Scarred/stiff bladder (neck) tissue			–
Accessory obturator vein			–
Prominent periprostatic veins			–
Large dorsal venous complex			–
Intra-abdominal adhesions			–

(*continued on next page*)

Table 1 (*continued*)

Parameter	Score[b]		
	Surgeon		ANT
	SgD	RoC	RoC
Osteophyte/bone spur (symphysis)			–
Friable urethral tissue			–
Further parameters[c]			–

ADT = androgen deprivation therapy; ANT = anaesthetist; eGFR = estimated glomerular filtration rate; HDR = high dose rate; HoLEP = holmium laser enucleation of the prostate; LDR = low dose rate; MRI = magnetic resonance imaging; NVBs = neurovascular bundles; RoC = risk of complications; SgD = surgical difficulty; TURP = transurethral resection of the prostate.

[a] To create the indices, four different parameter categories will be incorporated in the risk and difficulty estimation tool: preoperative (known, expected) patient-specific parameters; intraoperative (unknown or unexpected) patient-specific parameters; preoperative organ-specific parameters; and intraoperative organ-specific parameters (eg, fibrosed periprostatic tissue).

[b] Each item is scored as 0 = no or 1 = yes to indicate whether it will affect surgical difficulty or the risk of complications..

[c] Further parameters to be proposed by Delphi experts.

[d] Organ-specific factors for laparoscopic/robotic radical prostatectomy are presented as an example.

considered, and are integral to estimating procedural complexity and risk. Further details are outlined in Table 1.

The Delphi method, a validated consensus-building technique, will be used to develop best-practice guidelines for this concept. The process will involve multiple structured rounds, for which expert participants, including urologists, general surgeons, and anaesthetists, will be recruited via cross-institutional collaborations and contacted via e-mail. The target sample size is 50 participants, with follow-up for any withdrawals. Consensus will be defined as 75% agreement, and additional rounds will be conducted if needed. A steering committee of specialists will oversee the process. The process will initially focus on common urological procedures to establish organ-specific correlations with surgical difficulty and risk profiles. If these indices prove to be clinically applicable, they will undergo further evaluation in subsequent Delphi rounds and prospective validation in multicentre collaborative institutional settings.

The ultimate goals of predicting risk and surgical difficulty are to increase surgeon awareness of challenging perioperative conditions, reduce complications, and improve patient outcomes. Prediction also enables patients and families to better understand surgical risks. After estimation of individual risks, surgeries can be stratified to identify procedures suitable for teaching or training purposes.

While clinical judgment is essential, it alone cannot predict adverse outcomes following surgery [8]. New evidence continues to show that proper risk assessment can significantly improve patient outcomes. Various tools such as risk stratification calculators have been developed to provide a quantitative assessment of risk and identify high-risk cases. These rely on patient-specific variables for the construction of mathematical models that are calibrated using large data sets. While these tools offer a quantitative framework for performance tracking that allows comparisons of expected and observed outcomes among surgeons and centres, no current tool meets all the criteria for an ideal scoring system.

Learning curves highlight the link between experience and performance and offer insights into surgeon competency and procedural complexity. Factors such as technological advances, clinical guidelines, team consistency, and surgeon-specific attributes can influence learning trajectories. Stratification of learning curves by case volume integrates expertise into risk models, which can aid in procedure evaluation and identification of teaching opportunities [9,10]. Thus, our tool will not only account for patient and surgical factors but will also incorporate the influence of surgeon experience and learning curves on surgical outcomes.

The potential implications of this concept include better identification of high-risk cases, enhanced surgical planning, and greater preparedness for perioperative challenges in various minor and major procedures over the entire spectrum of urological surgery (eg, functional, uro-oncology, urolithiasis, andrology; Fig. 1). Organ-specific factors, combined with surgical approaches (endoscopic, open, laparoscopic, robotic), can form a checklist to assist in decision-making and identification of teaching cases (eg, in robotic interventions on a level of a training robotic console surgeon). The tool could promote transparency in patient counselling and improve the quality of patient consent and resource allocation. By allowing comparisons between surgeons and hospitals, the indices could also drive quality improvements and efficiency. In future, a secondary tool that incorporates these indices and surgeon/institution experiences could be created to compare risk between surgeons and centres and subsequently identify disparities in care.

An online calculator could streamline clinical adoption of the tool and provide accessible, validated risk assessment. If effectively implemented, the tool could also support clinical research and facilitate trials comparing outcomes and interventions across surgeons and hospitals.

While our tool is designed to enhance surgical planning and optimise patient outcomes, it is important to consider potential unintended consequences. Classification of cases as high risk could inadvertently lead to hesitation among both surgeons and patients and could potentially discourage the undertaking of necessary but complex procedures. This hesitation might result in patients missing out on surgical interventions that remain their best or only treatment option. Therefore, it is critical that risk stratification serves as a guide for informed decision-making rather than a deterrent to appropriate surgical care.

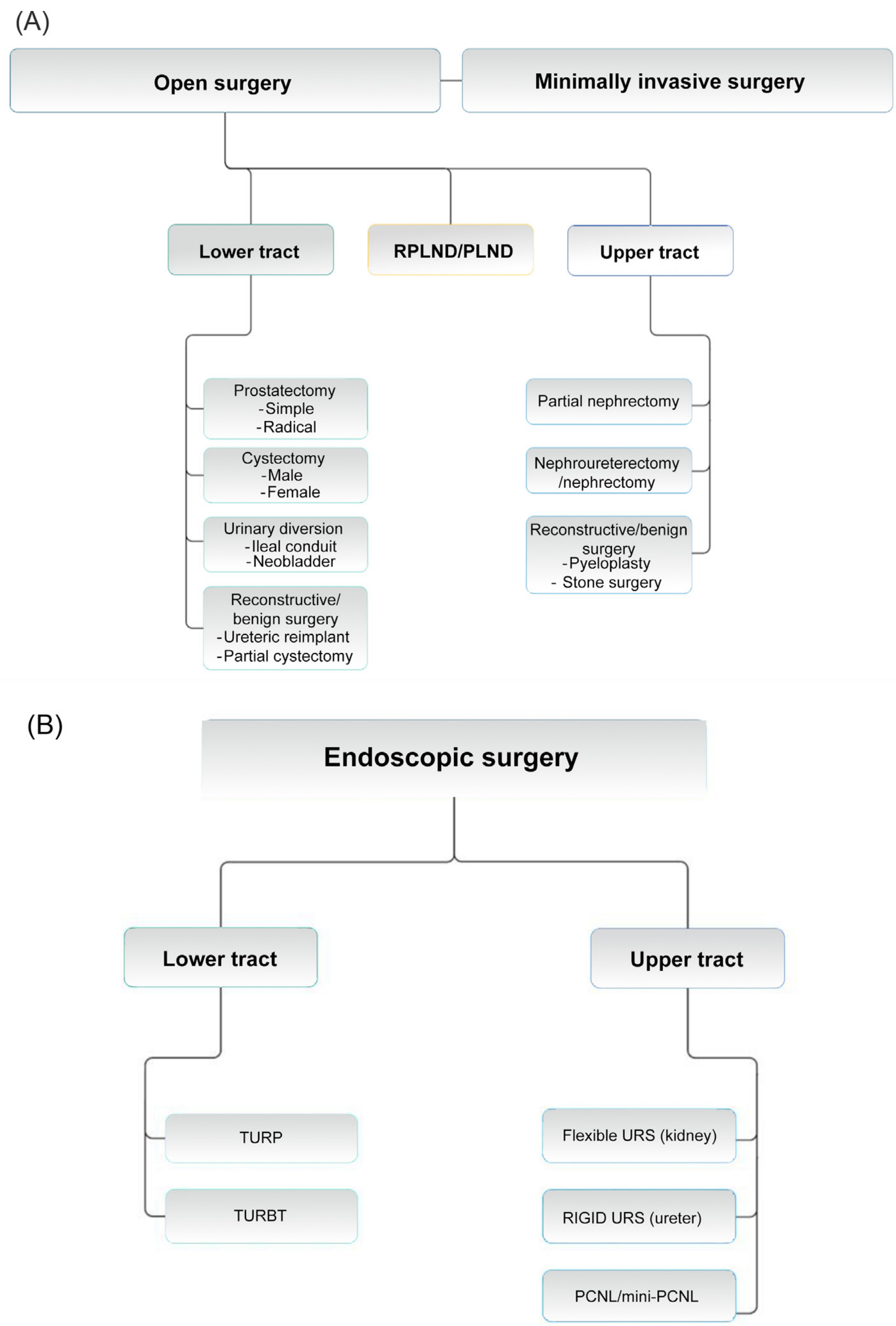

Fig. 1 – Overview of organ- and approach-specific interventions for which targeted organ-specific factors impacting surgical difficulty and the risk of complications in open, minimally invasive, and endoscopic surgery will be defined for an organ-specific scoring system. Frequent (A) major and (B) minor interventions that will be considered. PCNL = percutaneous nephrolithotomy; PLND = pelvic lymph node dissection; RPLND = retroperitoneal lymph node dissection; TURBT = transurethral resection of bladder tumour; TURP = transurethral resection of the prostate; URS = ureteroscopy.

The medicolegal implications of risk prediction tools must also be acknowledged. There is a possibility that numerical risk estimates could be misinterpreted or misapplied in legal or administrative contexts, and could influence treatment decisions or liability considerations in unintended ways. To prevent misuse, these tools should be positioned as adjuncts to clinical judgment rather than definitive arbiters of surgical candidacy to ensure that they support rather than constrain surgical decision-making.

To maximise the benefits of the tool while mitigating risks, it is essential to promote transparency in its design, validation, and application. A structured approach to implementation—grounded in robust clinical research and supplemented by clear guidelines on appropriate use—will help to ensure that the tool enhances surgical care without introducing unintended biases or restrictions.

In summary, there is emerging evidence that risk assessment significantly impacts patient outcomes. Preoperative functional assessment, prediction of intraoperative surgical difficulty, and consideration of unexpected intraoperative conditions all contribute to improving multidisciplinary decision-making, the allocation of critical care resources, communication with patients, and comparison of outcomes between surgeons and hospitals. Routine documentation of risk is crucial, particularly for high-risk patient groups and those undergoing technically challenging operations. Once validated and made accessible to the surgical community, our risk stratification tool could be integrated into standard preoperative and intraoperative assessments to enhance the overall quality of patient care.

Conflicts of interest: The authors have nothing to disclose.

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