Bridging the knowledge gap in urology residency: Unperceived challenges in assisting robotic prostatectomy

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ABSTRACT

Introduction: Urology training programs internationally have adopted robotic surgery, particularly robotic prostatectomy. We aimed to determine the knowledge gap in the understanding of robotic prostatectomy for residents compared to urologists, as there is a need for dedicated robotic training curricula.
Methods: A 16-question survey was developed, documenting the difference in understanding between residents and urologists. The survey contained items pertaining to patient anatomy, procedural steps, and surgical decision-making. The survey was completed immediately following a robotic prostatectomy by both the urology resident performing the bedside assistance, and the urologist. Statistical analysis of the quantitative questions was performed using kappa scores, and thematic analysis was performed to analyze the qualitative responses.
Results: Forty-two surveys were administered to urology residents and urologists at The Ottawa Hospital over 10 weeks. Disagreements were identified between urology resident and urologist responses. This was noted with the comparison of the following procedural steps: vesicourethral anastomosis (kappa 0.138), apical dissection (kappa 0.149), and seminal vesicle dissection (kappa 0.342). The qualitative responses found discrepancies between resident and urologist understanding. When asked to describe challenges during the procedure, urologists described causal factors leading to challenges and how to manage these issues intraoperatively. In contrast,

the residents' responses focused on readily visible aspects of the procedure, including bleeding or difficult exposure, omitting to describe the cause of these challenges.
Conclusions: There is a gap in urology resident knowledge and understanding of a robotic prostatectomy. This information is key to expand the understanding of robotic prostatectomy surgical decision-making and its training.

INTRODUCTION

Robotic surgery has revolutionized the surgical world, and notably the field of urology since its introduction in the early 2000s, with robotic-assisted laparoscopic prostatectomy (RALP) (Sheetz et al, 2020). Despite the widespread adoption of robotic-assisted surgery, a 2022 Journal of Robotic Surgery study highlighted the absence of a nationally standardized training curriculum for robotic surgeons and surgical teams in North America, emphasizing the need for a cohesive and validated educational framework (Collins et al. 2021).

As robotic-assisted surgery has become the gold standard for radical prostatectomy in numerous centers worldwide, teaching surgical residents this novel approach has presented significant challenges. The shift from traditional training methods—where residents typically learned by being scrubbed in at the operating table—has complicated the educational process (Rashid et al., 2006). Unlike open surgery, where residents directly observe and participate in the procedure under the supervision of the staff, robotic-assisted surgery places the primary surgeon at a console, with a physical distance between the patient and resident, and the primary surgeon.

Surgical education organizations, such as the Fundamentals of Laparoscopic Surgery and Fundamentals of Robotic Surgery, have made efforts towards the establishment of consensus on the core components of robotic surgery curricula (Fisher et al., 2015). Most of the current training curricula are focusing on teaching motor skills. To this day, there is no curriculum in robotic surgery focusing on teaching decision-making.

KEY MESSAGES

- When assisting in robotic prostatectomy, residents demonstrate a perceptual gap compared with attending surgeons. These gaps are most evident in complex steps involving deep or confined anatomical spaces.
- While surgeons focus on identifying underlying causes, residents tend to focus on observable consequences, indicating a cognitive difference in how robotic surgery is interpreted.
- High levels of agreement occur when clear anatomical landmarks are present, whereas the lowest agreement appears in recognizing tissue planes or hazard awareness.
- The findings highlight the need for a standardized robotic curriculum that incorporates cognitive training, perceptual skill development, and explicit intraoperative reasoning, rather than focusing solely on technical skill acquisition.

In current surgical training programs, the majority of operative skill acquisition occurs in the operating room, where both technical and cognitive skills are primarily developed (Pernar et al., 2011). Robotic surgeries, including robotic prostatectomies, require complex decision-making and rely heavily on visual cues to navigate and successfully complete the procedure (Tewari et al, 2010). Teaching residents to recognize and react to these cues and make appropriate decisions is critical to their development. Early in their training, residents focus on a limited number of intraoperative factors, in line with the cognitive load theory (Sewell et al., 2019). This often results in a gap in surgical awareness between staff surgeons and learners, with residents interpreting the surgical tasks as more demanding due to their lack of familiarity, which can lead to cognitive overload (Dias et al., 2018).

One universally recognized benefit of robotic surgery is the enhanced visual field, with reduced risk of surgical bleeding, improved precision, and superior tissue handling—all of which depend on the critical skill of understanding tissue planes and optimizing dissection (Reddy et al. 2023). This is especially relevant in procedures like RALP, where recognizing and navigating different tissue planes is essential (Coelho et al., 2010). However, identifying these tissue planes is an acquired skill, and there is a significant gap in accuracy between novice trainees and experienced surgeons (Schlachta et al., 2015). Addressing this gap creates an opportunity for the development of targeted training methods, such as simulated models, to better support trainee development (Schlachta et al., 2015).

Integrating surgical residents into robotic surgeries presents a notable learning curve, both for staff surgeons who must adjust their teaching strategies and for trainees who need to develop their skills with a less familiar tool. Given the increasing demand for dedicated robotic training programs, we sought to explore the gap in situational awareness during robotic prostatectomy between residents and urologists. Situational awareness has been defined as "the perception of elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future" (Endsley et al, 1995). Situational awareness has been identified as a critical skill to ensure safe surgical performance (Way et al, 2003). We hypothesized that residents and urologists would have a different perception of the surgeries. Documenting this gap could be the first step in identifying key components to include in a curriculum based on cognitive expertise and situational awareness. Moreover, currently residents play a more passive role in RALP, primarily assisting at the bedside rather than making decisions at the console. Other studies have described the challenges of observational learning for novice trainees and suggested the potential benefits of a more targeted cognitive aid for residents observing surgeries (Raiche et al, 2019).

This study serves as an initial step in exploring and quantifying the perception disparity that exists in the context of RALP surgeries, with the ultimate goal of developing targeted educational interventions to address these gaps.

METHODS

Research design

This study was conducted at the University of Ottawa. Ethical approval was obtained from the institutional research ethics board

Study participants

The study involved two groups of participants from The Ottawa Hospital (TOH); expert urologic oncologists performing robotic prostatectomy and urology residents bedside assisting with the procedure. All participating staff surgeons practiced at a single academic centre and had completed more than 200 robotic-assisted laparoscopic prostatectomies prior to study participation. Participants were recruited through convenience sampling, amongst resident rotating through the urology service and assisting robotic prostatectomy, ensuring representation of various levels of surgical experience (PGY-2 to PGY-4). Residents participated exclusively in the role of bedside assistant with variable number of robotic cases previously completed by individual residents depending on training level and rotation schedules. Residents demographics and experience level were not collected to protect their confidentiality. Informed consent was obtained from all participants before the survey. All participant data were anonymized, and confidentiality was maintained throughout the research process. Summary of characteristics of participants are listed in table 1.

Perception survey design

A structured survey was developed to assess residents' understanding of robotic prostatectomy and compare their perceptions with those of expert surgeons. The survey included both quantitative Likert scale scored questions and qualitative open-ended questions. The development of the survey was guided by an AMEE framework for survey design and refined through consultations with local medical education experts and urologic oncologists (Pangaro & Cate, 2013). The survey was piloted among a subset of residents and attending surgeons to refine question clarity and ensure relevance. A copy of the survey is attached as Appendix 1.

Data collection

Survey responses were collected immediately post-procedure to minimize recall bias. The responses were anonymized and stored securely.

Data analysis

Statistical analysis included percentage agreement and kappa statistics to evaluate concordance between resident and expert responses. Quantitative survey data were analyzed using descriptive statistics and inferential tests, including kappa analysis for inter-rater reliability. Percent agreement was determined for the quantitative data, between the staff and resident responses. Agreement refers to how consistent the responses are to one another. If the staff and residents gave the same responses, there was a high percent agreement versus if they gave very different responses and would have a low percent agreement (McHugh, 2012). The percent agreement is measured between the resident's response and the gold standard, or correct interpretation of the robotic prostatectomy, which is the staffs' response. The use of the kappa statistic takes this measurement one step further by taking into account random chance. For any question posed, the resident could give the same answer as the staff. This same answer however could be due to chance, a guess made by the resident. The kappa value aims to account for this chance. The following analysis used a statistically significant p-value of < or equal to 0.05. Open-ended survey responses underwent content analysis (Hsieh HF & Shannon, 2005), with coding conducted independently by two researchers.

RESULTS

Over a period of 10 weeks, 42 prostatectomies were observed, yielding forty-two pairs of surveys to compare.

Quantitative data results.

There were statistically significant differences of low agreement noted between the residents' responses and the staff surgeons' responses, specifically for the following questions: difficulty of the operation (k 0.393, p=0.117), patient anatomy (size of prostate) (k 0.2484, p=0.0379), seminal vesicle dissection (k 0.3358, p=0.0312), posterior dissection from the rectum (k 0.3201, p=0.0305), difficulty of neurovascular bundle spare (k 0.47, p=0.0425) and delay in progression (k 0.3387, p=0.0301). There were agreement between residents and staff surgeons which were statistically significant, including: whether the neurovascular bundles were spared (k 0.796, p<0.0001), difficulty of the bladder neck dissection (k 0.7125, p<0.0001) and whether there was more bleeding than expected (k 0.58645, p<0.0001). Table 2 summarizes these results.

Cohen's kappa was used to assess agreement beyond chance for ordinal Likert scale responses. For percent agreement analysis, responses were collapsed into two categories by grouping easy and moderately easy together and moderately difficult and difficult or very difficult together. Kappa values (−1 to +1) accounted for chance agreement, with statistical significance of $p \leq 0.05$. Although kappa measures overall concordance, it does not indicate how large the differences were when disagreement occurred. Notably, we identify that lower kappa values are clustered in higher difficulty operative steps such as posterior dissection, seminal vesicle dissection, and neurovascular bundle sparing, suggesting disagreement was linked to complex surgical phases.

Qualitative survey results

After the quantitative analysis, steps of prostatectomies were divided between steps where residents and surgeons were in agreement, and steps where their answers demonstrated a mismatch in their perception of the procedure. Table 4 presents the steps of a robotic prostatectomy divided by level of agreement.

To understand the disagreement in resident responses, descriptions from both residents and staff surgeons were coded into eight categories (e.g., exposure, anatomy, bleeding) and analyzed and collapsed into 3 themes. This analysis revealed three key differences in how residents explained their conclusions: (1) Cause vs. consequence – residents focused on the effects they observed, while staff described the underlying causes; (2) Negative vs. positive – residents highlighted challenges, while staff emphasized what went well; and (3) Positive vs. negative – the reverse, where residents noted successes and staff pointed out difficulties. These differences reflect varying perspectives and interpretations of intraoperative events. Table 4 presents examples for each category.

In examining the three themes listed in table 4 more closely, there are important contextual patterns that became apparent. The cause versus consequence distinction was most evident during technically complex portions of the operation, including particularly posterior dissection from the rectum, seminal vesicle dissection, apical dissection, and pedicle or neurovascular bundle dissection. In these steps, which correspond to higher levels of difficulty in the EAU RARP framework, residents frequently described visible outcomes such as bleeding, limited visualization, or perceived technical difficulty, whereas staff surgeons framed the same events in terms of underlying anatomical constraints such as a narrow pelvis, adherent tissue planes, prostate size, or tissue quality. The positive versus negative and negative versus positive framing differences were most observed during neurovascular bundle preservation and posterior bladder neck dissection. During these steps, staff surgeons described deliberate strategic adjustments, including modifying traction, repositioning robotic arms, or accepting controlled bleeding to preserve oncologic and functional outcomes, while residents often interpreted the same scenarios as either straightforward or more difficult based on surface features. These patterns suggest that perceptual differences clustered around surgical phases requiring anticipation, anatomical interpretation, and intraoperative risk management, particularly during deep pelvic dissection and nerve sparing where visual cues replace tactile feedback.

DISCUSSION

The results from this project describe the challenges in perception experienced by trainees as they are assisting robotic prostatectomies. Certain steps of the surgery seemed more easily understood that others namely the steps where known landmarks can guide the observation, when the visual field is wider and when residents can use pre-op imaging to guide their intra-operative perception. This is in accordance with previous literature describing the potential challenge for trainees to focus their attention on relevant aspects of surgeries (Raiche et al, 2019).

The training pathway for robotic-assisted radical prostatectomy (RARP) developed by Lovegrove et al. (2016) outlines procedural steps with corresponding levels of difficulty (I–IV) and was validated internationally by a multidisciplinary team, as seen in table 5. Interestingly, the results from the survey show that the level of perceptual agreement between residents and urologist does not follow the level of difficulty described in the RARP. This suggests that perception skills are slightly different than technical skills, potentially certain steps' difficulty is not based on perceptual challenges but more on technical execution challenges. Our results show a continuum where steps that are visually accessible and anatomically straightforward are easier to understand and assess, while those in confined spaces with limited visibility and no haptic feedback are more difficult to both comprehend and perform, illustrating the multifaceted nature of surgical difficulty in robotic procedures.

This suggests that cognitive difficulty during RALP is not only related to surgical and technical complexity, but also to the perceptual demands that is placed on the observer (Cope et all 2015) . Future educational interventions could influence this framework by pairing operative steps with cognitive teaching objectives, such as identifying causal mechanisms of bleeding, recognizing early hazard patterns, and verbalizing decision-making strategies during high-risk phases of the operation. These strategies could be implemented both intraoperatively and during postoperative debriefing. There could also be a role for educational videos focusing on those aspects of the procedure. A systematic review by Ahmet et al. (2018) on video-based education in surgical training demonstrated that structured video review can significantly enhance knowledge acquisition, technical performance, and cognitive understanding when integrated within a formal educational framework. Applying these principles to robotic prostatectomy training, including curated operative videos paired with guided commentary, pause-and-discuss strategies, and structured debriefing, could help residents better understand procedural flow, recognize tissue planes, anticipate hazards, and appreciate intraoperative decision-making. Such an approach may serve as a practical adjunct to bedside assisting while reinforcing perceptual and situational awareness skills outside the constraints of the operating room.

The category of cause versus consequence in residents' versus staff surgeons' explanations reflects a key concept in cognitive learning theory as described by Sewell et al (2019). Due to cognitive load, residents often focus on the visible outcomes of intraoperative challenges (e.g., bleeding, poor visualization), rather than identifying upstream causes (e.g., anatomy, tissue quality) as more experienced surgeons do. This is a natural limitation of novice learners who are still developing the cognitive capacity and clinical judgment required for complex surgical decision-making (Raiche et al, 2019). Dror emphasizes the importance of **error** recovery, not just error reduction, in training (I Dror 2011). Error recovery involves identifying an error, understanding how it happened, and formulating strategies to correct or avoid it. In surgical education, especially robotic surgery where bedside assistants have limited opportunities to actively manage intraoperative problems, residents often have limited opportunity to develop the mental framework to engage in this deeper level of reasoning.

Dror's approach suggests that to overcome this, surgical training must deliberately teach learners to link consequences to their causes. This means building curricula that allow residents to encounter and analyze surgical errors, both in real time and in simulation. Current robotic training programs focus on mastering procedural steps but often omit the structured teaching of how and why things go wrong (Aydin, Raison, Khan, Dasgupta, & Ahmed, 2016; Lovegrove et al., 2017, 2016). Integrating error recovery into robotic curricula can help residents develop the mindset of a primary surgeon earlier in their training, allowing them to shift from merely observing problems to understanding and managing them, ultimately improving both competence and patient safety.

The category positive vs negative can be linked to other expertise concepts. Expert perception has been known to be more accurate in various circumstances (Ericsson et al, 2006). This is usually attributed to experts' ability to process more information but also to focus their attention on more relevant information (Ericsson et al, 2006). In this study, residents could not recognize hazards that were apparent to the primary surgeons. These hazards, or potential near misses, occur during operations, however they can be identified, can be avoided and the procedure can proceed. If the residents could not recognize that these events occurred, they would not recognize them for future operations and this lack of awareness could potentially result in an actual intraoperative complication or issue, as compared to avoiding the error all together (Bonrath, Gordon, & Grantcharov, 2015). Bonrath et al assessed this concept of identifying error-event patterns by reviewing successful laparoscopic procedures and technical intraoperative event patterns (Bonrath et al., 2015). They were able to categorize these events for example as inadequate force on tissue or inadequate visualization, for better error awareness (Bonrath et al., 2015). The results from this study shows residents do not have a complete grasp of hazard awareness which can be addressed in the future for improved resident learning and potentially help avoid errors.

The category negative vs positive is probably a reflection of surgical teaching. Surgeons typically teach around errors in resident performance and less around their own explicit and beneficial surgical techniques (Roberts, Brenner, Williams, Kim, & Dunnington, 2012). In fact, Sutkin et al's description of surgical verbal teaching found that explanation by attending surgeons, was a small fraction of how attending surgeons communicate with residents intraoperatively (Sutkin, Littleton, & Kanter, 2015). Without being able to identify a surgical event as acceptable and/or beneficial, a resident might not be able to learn key manoeuvres in the surgery and/or could risk injury or intraoperative complications.

Future research should apply the perceptual frameworks identified in Table 4 to better interpret the agreement and disagreement patterns observed in Tables 2 and 3. Differences in ratings of procedural difficulty, bleeding, anatomical variation, or nerve sparing may reflect variations in cognitive interpretation rather than technical skill alone, with residents focusing on observable events and staff surgeons emphasizing underlying rationale. Integrating these qualitative categories into structured assessment tools and debriefings could improve feedback accuracy, clarify sources of discordance, and enhance competency-based surgical training.

Finally, there are some limitations to this study. Variability in prior robotic surgical experience among urology residents may have influenced survey responses. Additionally, differences in attending surgeons' teaching styles and intraoperative guidance could affect the decision-making cues emphasized during the procedure. Other factors, such as patient anatomy, case complexity, and intraoperative complications, were acknowledged as potential confounders. This study was conducted at a single academic institution and used a convenience sample of attending surgeons and residents available during the study period. Participation was influenced by operative schedules and rotation timing, resulting in a relatively small number of staff and resident participants. Although the sample size was adequate to explore perceptual agreement within this context, multi-institutional studies with larger cohorts may further clarify the applicability of these findings across different centers and training levels.

CONCLUSIONS

This study highlights an important knowledge and perceptual gap between urology residents and staff surgeons during robotic-assisted laparoscopic prostatectomy. The data showed that although residents are important participants and actively assisting in the surgery, their ability to interpret critical intraoperative events and appreciate decision-making cues differs from that of the experienced primary surgeons. These differences are particularly evident during complex steps involving intricate tissue planes, confined operative fields, and nuanced anatomical variations. These represent factors where visual cues inevitably replace the traditional tactile feedback available during open surgery.

Residents often interpret surgical events through observable consequences such as bleeding or difficult exposure, while staff surgeons identify upstream causes and apply strategic corrections. These differences reflect cognitive disparities rooted in experience, clinical reasoning, and situational awareness.

To bridge this gap, surgical training programs could be modified to allow training beyond technical skill acquisition, and include that of cognitive training as a core aspect of skill acquisition. Gaining the knowledge for error recognition, cause-consequence reasoning, and hazard awareness will be essential in equipping residents with the decision-making frameworks necessary for robotic surgery. Structured teaching strategies, targeted simulation modules, and debriefing methods focused on cognitive and perceptual learning may help trainees transition for a more advanced level in robotic training.

Overall, by identifying hidden challenges in robotic surgery training, we aim to address curricular gaps and better support resident skill acquisition.

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FIGURES AND FIGURES

Table 1. Summary of characteristics of participants		
	Surgeon	**Resident**
Role	Console-based primary surgeon	Bedside assistant
Training level	Staff urologist at an academic center	PGY-2 to PGY-4
Prior robotic experience	>200 RALP cases	Variable depending on level of training

Table 2. Summary of the quantitative results	
Agreements	**Disagreement**
Difficulty of the lymph node dissection Difficulty of the bladder neck dissection Belief on whether the neurovascular bundles were spared Perception on whether there was more bleeding than expected	Overall difficulty of the operation Perception of variations in patient anatomy Difficulty of seminal vesicle dissection Posterior dissection from the rectum Difficulty of neurovascular bundle spare Delay in progression during different surgical steps

Table 3. Steps of the procedures divided by agreement and disagreement.	
Agreements	**Disagreement**
Difficulty of the lymph node dissection Difficulty of the bladder neck dissection Difficulty of nerve spare (if easy)	Describing the most difficult part of the surgery Difficulty of seminal vesicle dissection Difficulty of posterior dissection from the rectum Difficulty of apical dissection Difficulty of the vesicourethral anastomosis Complication identification Identification of anatomical landmark

Table 4. Example of each category	
Category	**Example**
Cause vs. consequence	**Posterior dissection** Residents and staff surgeons gave similar assessments of posterior dissection difficulty when anatomy was normal. However, when the dissection was more challenging, residents struggled to explain why. Residents focused on what they observed (e.g., bleeding, poor

	visualization), while staff surgeons identified underlying causes (e.g., sticky tissue planes, small pelvis) that led to those challenges. Add other example here
Positive vs. negative	**Unnoticed adjustment of the robotic arms** The staff surgeon shifted the robotic arms to assist the dissection, gaining range of motion in the robotic arms or facilitate further dissection in deep areas without the resident noticing it. The resident assumed the dissection was easy but it required multiple extra adjustments from the urologist to overcome complex anatomy. Challenging retraction The primary surgeon has to change the retraction of a robotic arm to facilitate visualization or tension of tissues which, because it is not directly in the operative field, the resident would not be able to appreciate
Negative vs. positive	**Allowing bleeding to avoid injury** The staff surgeons purposefully allowed bleeding to occur around the neurovascular bundles and avoided the use of cautery to avoid nerve injury. The residents noted excessive bleeding while the staff surgeon deemed the bleeding appropriate. **Bladder incision** Surgeons also described deliberately creating a larger bladder neck opening that subsequently requires reconstruction but avoids incising into the prostate, potentially having a positive surgical margin and subsequently leaving cancer behind

Table 5. EAU RARP condensed level of difficulty score

Level of difficulty	Step
I	Robot setup Pneumoperitoneum and port placement Initiation of console Inspection of abdomen at end Finalizing-removing instruments and ports
II	Adhesiolysis Drop bladder Exposure of prostatic apex and fascia Dividing DVC
II/III	Anterior bladder neck dissection
III	Posterior bladder neck dissection SV dissection Posterior dissection Vesico-urethral anastomosis Lymph node dissection
IV	Pedicles/neurovascular bundles Apical dissection