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TOPIC PAPER

Using video review to understand the technical variation of robot-assisted radical prostatectomy in a statewide surgical collaborative

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Abstract

Purpose Video assessment is an emerging tool for understanding surgical technique. Patient outcomes after robot-assisted radical prostatectomy (RARP) may be linked to technical aspects of the procedure. In an effort to refine surgical approaches and improve outcomes, we sought to understand technical variation for the key steps of RARP in a surgical collaborative.

Methods The Michigan Urological Surgery Improvement Collaborative (MUSIC) is a statewide quality improvement collaborative with the aim of improving prostate cancer care. MUSIC surgeons were invited to submit representative complete videos of nerve-sparing RARP for blinded analysis. We also analyzed peri-operative outcomes from these surgeons in the registry.

Results Surgical video data from 20 unique surgeons identified many variations in technique and time to complete different steps. Common to all surgeons was a transperitoneal approach and a running urethrovesical anastomosis. Prior to anastomosis, 25% surgeons undertook a posterior reconstruction and 30% employed urethral suspension. 65% surgeons approached the seminal vesicle anteriorly. For control of the dorsal vein complex, suture ligation was used in 60%, and vascular stapler was 15%. The majority (80%) of surgeons employed clips for managing pedicles. In examining patient outcomes for surgeons, peri-operative outcomes were not correlated with surgeon's operative time; however, surgeons with an EBL > 400 ml had significant difference among the five different techniques employed.

Conclusions Despite the worldwide popularity of RARP, the operation is still far from standardized. Correlating variation in technique with clinical outcomes may help provide objective data to support best practices with the goal to improve patient outcomes.

Keywords Prostate cancer · Radical prostatectomy · Robotic surgery · Technique · Video assessment

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Introduction

Robot-assisted radical prostatectomy (RARP) is the mainstay surgical treatment for organ-confined prostate cancer in the United States [1]. Contemporary data now support equal to superior results with robotic-assisted approach compared to traditional open surgery [2]. Despite the widespread adoption RARP over the last decade, a clear understanding of the variation in the technique remains to be established. Moreover, patient outcomes may be linked to the technical aspects of the surgery [3]; however, the assessment and comparison of data may be hindered by a lack of knowledge of the various techniques currently in use.

Robotic and laparoscopic systems afford more feasibility to capture and review surgical videos of all steps of a procedure. Surgical video review is an emerging technique that allows a greater understanding of the technical aspects of surgery, and has important implications for surgical training, quality improvement, and lifelong learning [4, 5]. De-identified, unedited videos allow for blinded, unbiased review. The Michigan Urological Surgical Improvement Collaborative (MUSIC) group has previously reported the use of expert peer surgeon and layperson crowd-sourced review to assess the technical skills of qualified urological surgeons performing key steps of RARP [6]. However, this prior study lacked consideration of the technical variations among surgeons. Although a surgeon's skill may play a role in the success and outcome of surgery, surgical technique presents another unique variable that may influence outcomes.

To better understand the technical variation present in modern day RARP, we analyzed complete surgical videos of RARP performed by surgeons in a statewide collaborative. Our goals were to classify the key steps of RARP and understand those techniques that are more universally adopted or widely vary among surgeons, a cornerstone to well established surgical procedures with better outcomes.

Methods

Data source

The Michigan Urological Surgery Improvement Collaborative is a statewide quality improvement consortium funded by Blue Cross Blue Shield of Michigan comprising of 44 diverse community and academic practices representing 260 urologists in the State of Michigan. The goal of MUSIC is to improve the quality and cost efficiency of prostate cancer care for men in Michigan. Urologists participating in the collaborative were asked to voluntarily submit a representative video of nerve-sparing RARP for the purposes of surgical video review and technique evaluation.

Study design

Video review was completed after unedited videos were stripped of patient and performing surgeon identifiers. The duration to complete major steps of the surgery was recorded systematically into a database by one independent video abstractor, who had experience of watching > 100 RARP cases in the operating room. The major steps of RARP were analyzed according to eight key steps: (1) bladder takedown; (2) endopelvic fascia incision; (3) dorsal venous complex control; (4) bladder neck dissection; (5) seminal vesicle dissection; (6) nerve sparing and pedicle control (including posterior dissection); (7) apical dissection; and (8) urethrovesical anastomosis (including posterior musculofascial plate reconstruction or urethral suspension, if performed). The variations in task performed during each step of the surgery were analyzed. To minimize video review burden, only console time to perform the surgery was analyzed.

We also collected the notable outcomes and trackable events after surgery (NOTES) of these surgeons in the MUSIC registry. NOTES is a recorded peri-operative assessment for actionable data points that collectively reflect practice patterns and resource utilization, technical complications, and coordination of care [7]. We focused on the peri-operative outcomes of estimated blood loss (EBL) during surgery (recorded as above 400 ml or not), readmission rate within the first 30 days after surgery, and mortality. It is an accumulated surgeon level outcome rather than an outcome from a single patient, such as that indicated by the specific video recorded.

Analysis

The variation in time to complete each step was evaluated and calculated for mean time and ranges (minimum and maximum times) of each step. Descriptive statistics of variations are provided for each step and utilize Wilcoxon rank-sum test to calculate statistical significance for those steps with a wide range. The correlations between surgical outcomes and procedural time were evaluated and calculated by Pearson correlation coefficient. We also used Chi-squared test to analyze the EBL in different DVC controlling categories (SAS version 9.4).

Results

A total of 20 videos by unique surgeons were reviewed and analyzed. All cases were performed using the da Vinci surgical system through a transperitoneal approach. While posterior and anterior approaches were observed, in all cases, the dissection of the prostate progressed in an antegrade fashion.

Time analysis

The mean robotic operative time was 100 min (range 72–157 min). The mean time (range) to complete the major steps of surgery was: (1) bladder takedown: 9.4 min (2–24); (2) endopelvic fascia dissection: 6.9 min (3.5–11); (3) dorsal venous complex (DVC) control: 5.3 min (2.3–10.5); (4) bladder neck dissection: 13 min (6.7–30); (5) seminal vesicle dissection: 16.3 min (9–32); (6) nerve sparing and pedicle control: 17.4 min (8.3–33.3); (7) apical dissection: 7.7 min (3.9–17); and (8) urethrovesical anastomosis: 24.1 min (16.7–43.5). The operative time with the key steps for each unique surgeon is displayed in Fig. 1.

Variations in task performed

For seminal vesicle dissection, 13 surgeons (65%) performed this via an anterior approach vs. 7 surgeons (35%) who performed a posterior approach. Mean time for surgeons performing anterior approach was 15.3 min (range 9–28.6), while mean time for surgeons performing posterior approach was 18.3 min (range 10.3–32). The difference between anterior and posterior approaches was insignificant ($p = 0.579$) and great variance among surgeons of up to 20 min for both methods observed (Fig. 2). There is a wide variation in time (more than 20 min from min to max) to complete the steps, including bladder takedown, SV dissection, bladder neck dissection, managing pedicle/nerve-sparing, and urethrovesical anastomosis, while the others had similar times with narrow variations.

For nerve-sparing and pedicle control, the majority of surgeons ($n = 15$; 75%) utilized Weck Hem-o-lok clips (Teleflex, Morrisville, NC, USA). Mean time to perform the task for surgeons using Weck clips was 17.6 min (range 10–33.3). Enseal Bipolar (Ethicon, Cincinnati, OH, USA) was used by four surgeons, and mean time was 14.6 min (range 8.33–28.4). One surgeon employed titanium clips for pedicle control and time to perform the task was 25 min.

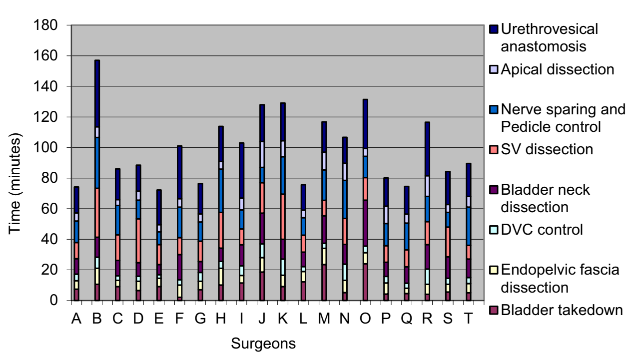

Fig. 1 Time to complete major steps of robot-assisted radical prostatectomy for surgeons in a surgical collaborative. *DVC* dorsal venous complex, *SV* seminal vesicle

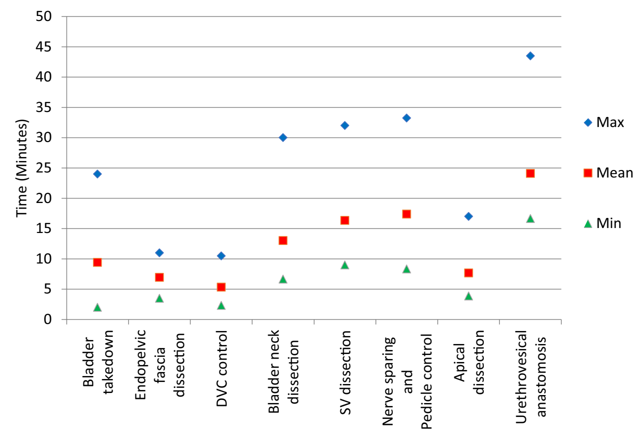

Fig. 2 Mean time (including range) to complete each major step of robot-assisted radical prostatectomy for surgeons in a surgical collaborative. *DVC* dorsal venous complex, *SV* seminal vesicle

For the management of the DVC, the majority of surgeons ($n = 12$; 60%) utilized a suture ligation method. Mean time to perform the task was 5.6 min (range 3.25–10.5). Ten surgeons used non-barbed suture to perform suture ligation, while two surgeons chose barbed suture. Three surgeons employed a vascular stapler to control and divide the DVC; mean time was 3.4 min (range 2.33–4.5). Two surgeons utilized both suture ligation and then vascular stapler to control the DVC with a mean time to perform the task was 5.8 min (range 4.3–7.25). Two surgeons elected to cut and over sew the DVC with a mean time to perform the task of 6.7 min (range 2.9–10.5). One surgeon entrusted electrocautery alone to control the DVC over an elapsed time of 4 min.

For urethrovesical anastomosis, all surgeons displayed a running suture technique. Twelve surgeons chose a non-barbed suture with mean time to perform this task of 24 min (range 17–43.5) compared to eight surgeons electing a barbed suture with mean time to perform task of 24 min (range 16.67–35). Prior to performing the anastomosis, additional steps were undertaken including: three surgeons performing posterior musculofascial plate reconstruction, four surgeons adding a urethral suspension, and two surgeons including a musculofascial plate reconstruction and urethral suspension. The surgeons ($n = 2$) who performed both posterior musculofascial reconstruction and urethral suspension had longer times for the urethrovesical anastomosis of 39.25 min compared to mean time for surgeons ($n = 11$) who did not perform either was 21.6 min (range 16.67–34.5). After finishing the anastomosis, 10 surgeons performed bladder leak test, and 11 surgeon performed surgical drain placement, regardless of the leak test. Of note, two surgeons utilized suprapubic tubes instead of Foley urethral catheter for bladder drainage.

There were no mortalities recorded in these 20 cases. An EBL of > 400 ml among surgeons performing RARP ranged from 0.0 to 10.0% (median rate 1.4%). The 30-day readmission rates ranged from 1.7 to 12.7% (median rate 5.0%). Both outcomes showed no significant statistical relationship with total surgical time. In subset analysis of the time to complete bladder neck dissection, which incidently had the widest range in surgical procedural times, demonstrated no statistical significance with blood loss or readmission rates (Fig. 3). Surgeons with an EBL > 400 ml had significant difference among five different techniques employed, as shown in Fig. 4 ($p < 0.01$).

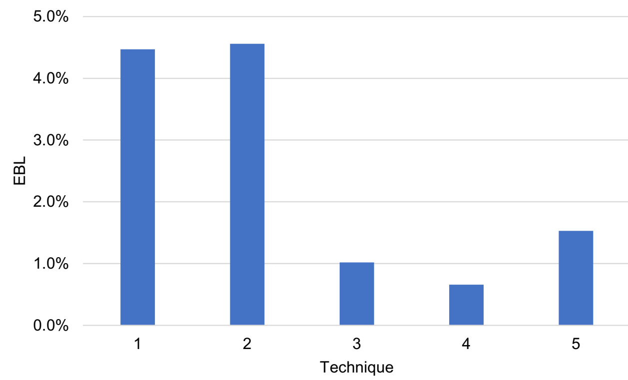

Fig. 4 Estimated blood loss among different techniques applied for dorsal venous complex controlling in a surgical collaborative. *EBL* estimated blood loss, ratio of more than 400 ml or not; *Technique 1* suture ligation; *Technique 2* electrocautery alone, *Technique 3* vascular stapler, *Technique 4* suture ligation combined with vascular stapler, *Technique 5* cut and over sew

Discussion

We reviewed unedited surgical videos for the analysis of the key steps in RARP from 20 unique surgeons in a statewide collaborative. Considerable variation was found in most steps of the procedure. Eight procedural steps were identified. Variation was seen for (1) time to complete each step of RARP, (2) methods for DVC control, (3) nerve-sparing technique and pedicle control, and (4) performance of the urethrovesical anastomosis. To our knowledge, this is the first study analyzing RARP technique from surgeons across practices, and may represent pragmatic real-life practice patterns vs. a single-institution or single-surgeon review.

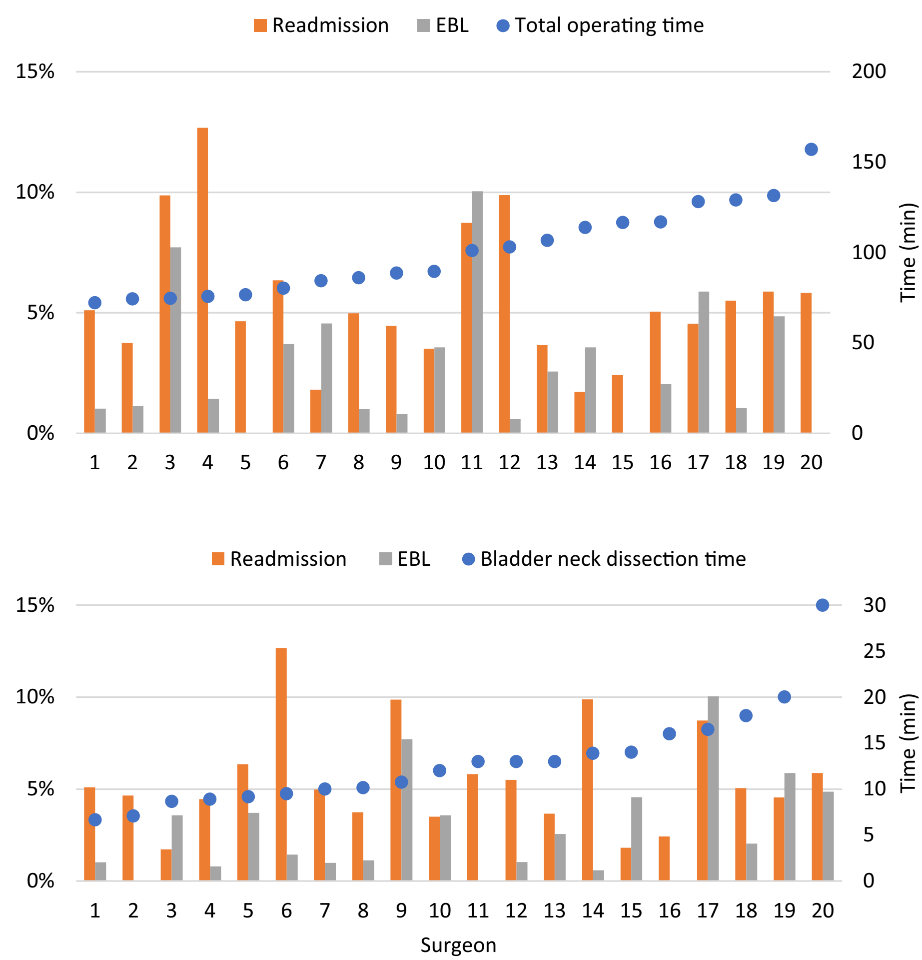

Fig. 3 Correlation ship between surgical time and outcomes, readmission rate and rate of estimated blood loss more than 400 ml, in a surgical collaborative. The upper one is total operation time and lower one is bladder neck dissection time. Notice the surgeon is ordered by the surgical time, not the fixed surgeon labeled as in Fig. 1. *EBL* estimated blood loss, ratio of more than 400 ml or not

Eight key, procedural steps were identified, which matched closely with the seven steps previously published by Huynh et al. [8], although they combined DVC control and apical dissection in one step. Intuitively and historically, surgeons often equate operative time as a key measure of skillful operation. Daley et al. reported that an increase in operative time correlated with increased peri-operative morbidity [9] and Birkmeyer et al. showed a correlation with longer operative time and lowest quartile of technical skill, as judged by expert peer surgeons on video review [3]. These studies, however, do not account for variations in technical aspects of the surgeries. In our limited study, surgical time did not correlate with surgical outcomes, although with a greater understanding of various techniques, further study with greater surgeon videos may provide greater insight. Optimally, if one could correlate time to complete specific step (like urethrovesical anastomosis) to patient outcomes, then minimal standards could be established. However, considerable technical variations and patient anatomical variations may influence time, beyond the surgeon skill and experience. Prior art has provided some basis for time and outcomes. In one study, the expert with more than 100 RARP cases had more efficient movement and less tissue trauma, which may lead to better outcomes and less surgical time [10]. Furthermore, prior studies support that surgeons dedicated to continuous improvement in performance, even after becoming an expert, resulted in further improvement in several aspects including operative time and peri-operative outcomes [11].

Performing or omitting certain tasks will also affect the overall operative time and hence, may not fully correlate with surgical skill. For example, the mean time to complete urethrovesical anastomosis with both posterior reconstruction and urethral suspension was observed to be longer than doing without reconstruction in the present study. Furthermore, a surgeon's delicacy of dissection may result in time differences. For example, some surgeons added additional time to complete a bladder neck preservation during bladder neck dissection, while other surgeons opened the bladder neck widely and reconstructed later during the case. A time difference was also observed in seminal vesicle dissection, a variance that may be accountable to surgeon skill or variable anatomy or patient conditions (such as difficulty in identifying seminal vesicles with a high median lobe, enlarged prostate in the anterior approach, or difficulty in identifying the seminal vesicle from the posterior aspect) [12]. The wide variation in surgical time during SV dissection, as well as the anastomosis, highlights these steps as one of the key parts of RARP that make operative time longer among surgeons and lends itself to further study on more efficient dissection or the need for technical refinement.

One of the major concerns in RARP is the recovery of erectile function. Although the majority of surgeons in this study (80%) employed non-thermal fashion to preserve the neurovascular bundle with cold scissors and clips to control the pedicles, some surgeons used energy sealants. The use of energy sealants during nerve-sparing is one area of frequent debate, with some advocating no, minimum, or pinpoint cautery on low-energy settings [2]. Furthermore, the method of nerve-sparing has wide variation such as inter-facial, intra-facial, extra-fascial, or high-release—which we did not catalog in our study [13]. Even with detailed reviewed of a statewide cohort of surgeons, there are still some techniques previously described or unrecognized yet among the RARP community, which may enhance a patient's continence and potency. For example, de Carvalho et al. described a retrograde release of the neurovascular bundle with preservation of DVC to enhance both continence and potency in a single-surgeon's experience [14]. By identifying techniques, future study of patient continence and erectile function outcomes correlated with the use of different methods of pedicle control and nerve sparing will help provide evidence-based recommendations for best practices.

For continence consideration, many surgeons believe that the urethrovesical anastomosis plays an important role; however, other technical aspects may influence outcomes, such as adjacent structure reconstruction and nerve preservation [15]. Reconstruction techniques include musculofascial plate reconstruction, which was first reported by Rocco et al. in 2011 [16] and then modified for laparoscopic surgery [17, 18]. Urethral suspension technique was described by Walsh [19] for open radical prostatectomy and Patel and co-workers [20] for RARP. Hurtes et al. [21] reported the first series combining these two reconstructive steps [22]. While some may feel that these reconstructive procedures are time consuming without evidence-based data, others believe and employ these in an attempt to improve urinary continence based on personal experience or small series [23].

Despite multiple reconstructive tasks for urethrovesical anastomosis observed in our cohort, all surgeons employed a continuous stitch, although some used a barbed suture. Early experience in laparoscopic and robotic surgery mimicked open techniques, using an interrupted anastomosis technique [24]. Over time, however, growing experience and reported outcomes were superior with continuous (vs. interrupted) [25, 26]. Subsequently, a running anastomosis became the standard technique for RARP. While the running anastomosis has been widely employed, there are still new techniques that make the anastomosis more efficient like the barbed suture method [27, 28].

The control of the DVC was another surgical step with multiple (5) techniques observed. There were many issues discussed regarding DVC control techniques including the most focus on surgical positive margin and EBL. EBL showed static difference among different techniques was consistent with prior study which suture and stapler were performed by a single surgeon [29].

Video review and assessment is a great tool to learn variation in surgical technique; however, robotic surgery videos do not capture all aspects of the surgical team's assistance such as communication and non-verbal cues that can lead to outcome differences [30]. In addition, while all our videos were for nerve-sparing cases, we did not include pathology/staging data, which is an important factor for technique during RARP [31]. Other factors may play a role in the time that it takes to complete a step, variance of techniques, and patient outcomes. One of the limitations of this study is the lack of the patient's characteristics, and long-term functional and oncological outcomes. However, the aim of this paper, which claimed no comparison among different techniques, was to examine the variation in the techniques among a focused group of surgeons within a statewide collaborative team. The video was selected as a representative case of low-to-intermediate risk disease, what would be considered a typical case without difficult anatomy and morbid obesity. As residents and fellows enter their own clinical practices, they start introducing their own variation to the surgery and this may have accounted for some of the differences observed in the many steps. Although the surgeon number is relatively small, it was the first statewide surgeon from both private and academic institution performing RARP, which could be closer to the basis in the real world, for our best knowledge. For example, the video review work from the bariatric surgeons [4] also featured data from 20 surgical videos, and our work is similar in that respect. Future efforts from our group will acquire larger samples and make more comparisons to give more reinforce in identifying if a task is necessary or not.

Despite the worldwide popularity of RARP, the operation is still far from "standardized". Varied techniques were utilized for different key steps that may lead to different outcomes. In the preset cohort, we observed steps with a wide range of variation, while some only differed in the suture selection; less variance may suggest more standard and well-recognized techniques. Alternatively, further studies may focus on steps with the most variability and correlate with outcome data. The goal is to expand our knowledge and reach a consensus for the steps and techniques of RARP with the aim to improve patient outcomes.

Conclusion

In this study, surgical video review demonstrated variation in the major steps of RARP for surgeons participating in a statewide surgical collaborative. Different techniques are employed and there is also a wide range in the time to complete each task for several key steps. Correlating variations in technique with clinical outcomes may help provide objective data to support best practices with the goal to improve peri-operative and functional patient outcomes.

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Author contributions KRG: manuscript editing and project development. WKJ: manuscript editing and project development. ZJP: data collection or management and analysis. PP: manuscript writing and analysis. TK and other: project management. EK: manuscript editing and other: project oversight. SL and other: obtaining funding. DCM: manuscript editing. JOP: manuscript editing and other: project oversight. JT: data collection or management. JQ: data collection or management and analysis. RCW: manuscript writing and data analysis.

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Compliance with ethical standards

Conflict of interest Both Dr. Miller and Dr. Ghani receive support from Blue Cross Blue Shield of Michigan for serving the MUSIC as program directors. Dr. Miller receives grant support from the National Cancer Institute. Dr. William Johnston III is a speaker for Janssen and Pfizer and on the advisory board for Ethicon/Verb Surgical.

Research involving human participants This study was a retrospective review de-identified video. We did not obtain patient's characteristics and there is no issue involving human participants.

Informed consent This study is aim to classify the key steps of the surgery and understand technical aspect. There is no issue on patient's identifiable dates.

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