The Use of Barbed Suture for Cystotomy Repair — A Novel Approach

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Research article

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Abstract

Background

In this study, we aim to compare outcomes after cystotomy repair between standard sutures (910 polyglactin, poliglecaprone) versus barbed (V-Loc™ 90) suture. As a secondary outcome, we analyzed risk factors for suture preference between the two groups.

Methods

A retrospective chart review was undertaken for surgeries complicated by cystotomy, identified by ICD-9/10 codes from 2016 to 2019 at West Virginia University (WVU) Hospital. Comparisons were made between cystotomy repair using barbed suture versus standard braided suture. Injuries were categorized by procedure, surgeon specialty, surgical route, type of suture used in repair, and subsequent complications related to repair. Primary endpoints were examined by Pearson's Chi-square test and interval data by t-test. A $p < .05$ was significant.

Results

Sixty-eight patients were identified with iatrogenic cystotomy at WVU. Barbed suture was used for cystotomy repair in 11/68 (16.2%) patients. No significant difference was seen in postoperative outcomes between patients repaired with barbed suture versus standard braided suture. Barbed suture was significantly more likely to be used for cystotomy repair in minimally invasive surgery ($p = 0.001$). It was most often utilized in a robotic approach 7/11 (63.6%) followed by laparoscopic 3/11 (27.3%). Body mass index (BMI) was significantly higher in patients receiving a barbed suture repair ($p = .005$).

Conclusion

Barbed suture is not inferior to standard braided suture for cystotomy repair and does not cause an increase in complication rate. Barbed suture offers a practical alternative to facilitate cystotomy repair in minimally invasive surgery, especially in patients with a high BMI.

Background:

Urinary tract injuries are a feared complication of any pelvic surgery. It has been shown that urinary tract injuries occur in 0.2-1% of all pelvic operations especially in those with pelvic adhesion or distorted anatomy [1]. Seventy five percent of iatrogenic injuries occur during gynecologic procedures due in part to the close proximity of the genital and urinary tract [2, 3]. During open and laparoscopic procedures, injuries are most likely to involve the bladder, followed by the ureter [4].

Many cystotomy repair techniques have been studied including the mechanism and instruments needed for repair. Bladder injuries are graded from 1–5 ranging from contusion or partial thickness laceration to laceration extending into the neck or trigone of the bladder (Fig. 1). The degree of damage to the bladder determines the level of repair; grade one or two injuries require no immediate repair and placement of Foley catheter for 7–14 days after surgery. However, grade three and above require immediate surgical repair in the form of a cystotomy repair [5]. The traditional closure of an iatrogenic bladder laceration requires intraoperative repair in two layers using absorbable sutures followed by back-filling the bladder to observe no urinary leakage [6]. Achieving this laparoscopically can be difficult to master, requiring many hours of practice to gain proficiency. Figert et al. concluded from their study that specific training and experience are needed to develop such laparoscopic skills [7].

Laparoscopic surgery can present multiple anatomical and physiologic challenges within the pelvis, especially when a urologic injury is encountered. Some of these challenges include decreased visualization due to limitations in patient positioning, excess peritoneal fat, redundant colon, and imperfectly placed instruments [8]. To avoid having to open the patient to facilitate a repair of a urologic injury, techniques to mitigate these challenges should be implemented.

Barbed suture, such as the V-Loc 90, was first used in gynecologic procedures in 2008 and demonstrates many advantages over conventional laparoscopic suturing and knot tying [9]. Barbed suture has been shown to shorten training time, reduce operating room cost, increase safety, and potentially improve the outcome in a laparoscopic setting [9, 10]. The design of the barbed sutures incorporates unidirectional or bidirectional barbs allowing for tension to be distributed evenly along a suture line. Barbed sutures were observed to be superior to Monocryl and Vicryl in a rabbit bladder model study [11]. In another study using porcine bladders, it was found that using barbed sutures significantly reduced operative time while providing easier tissue approximation [11].

In this study, we aim to compare outcomes of traditional suture repair of urologic injury during open surgery to laparoscopic repair using a barbed V-Loc suture. As a secondary outcome, we analyzed risk factors for long-term sequalae between the two groups.

Methods:

This is a retrospective cohort study using the medical records from West Virginia Medicine healthcare system. IRB approval for this study was acquired by the West Virginia University Institutional Review Board (approval number 1909723019). In this study, we identified the patients based on a query of electronic medical records using current procedural terminology codes and ICD-9 diagnosis. The search was performed from January 2016 – September 2019. For all bladder repairs we used the CPT codes: 51860 cystorrhaphy, suture of bladder wound, injury or rupture and 51040 incision procedures on the bladder. Patient charts were retrospectively reviewed by A.S. and information was obtained on basic demographics and surgical history. Injuries to the bladder were recorded along with type of surgery (gynecologic, urologic, other), manner of surgery (open, laparoscopic, robotic), cause of injury (trauma,

iatrogenic, unintended), total operative time, post-operative studies (fluoroscopy, voiding trial), time to foley removal, length of hospital stay, and mechanism of repair (open, laparoscopic, robotic). Total operative time included the length of the primary procedure with bladder repair. All bladder injury repairs were evaluated by recording the suture material that was used (Monocryl ™, Vicryl ™, or Barbed V-Loc ™). Monocryl suture is a synthetic absorbable monofilament suture derived from a segmented copolymer of ε-caprolactone and glycolide. Vicryl suture is a braided absorbable suture made from 90:10 poly (glycolide-co-L(-)-lactide). Barbed V-Loc suture is a synthetic absorbable unidirectional barbed suture prepared from a synthetic polyester composed of glycolide, dioxanone, and trimethylene carbonate. Vicryl and Monocryl are traditionally used in bladder repair and their use is based on surgeon preference. All patients underwent a standard general anesthetic. Any complications in subsequent patient encounters were also recorded. Complications were defined as any urinary symptoms or complaints that developed following the recorded surgical procedure. Statistical analysis was performed with Pearson's Chi Square test of association and interval data by t-test. A $p < .05$ was significant.

Results:

Our review incorporated 68 patients with a mean age of 52.2 ± 20.1 years. There was an almost equal representation of gender with 35 males (51.5%) and 33 females (48.5%). BMI is an important consideration in surgery especially with respect to technical difficulty and potential for complications. While the mean BMI of our study was technically overweight (27.5 ± 7.9), a significant portion of patients fell into the normal (39.7%) and obese (33.8%) categories based on BMI. The complete demographic breakdown is summarized in Table 1. No differences were noted with respect to operative time, post-operative fluoroscopy (if ordered), time to foley removal (if placed), and hospital length of stay. These results are listed in Table 2.

Table 1
Patient demographic characteristics

Characteristics	N (%)
Age	Mean: 52.2 ± 20.1
Gender	Female: 33 (48.5) Male: 35 (51.5)
Race	White: 67 Asian: 1
BMI	Underweight (< 18.5): 6/68 = (8.8%) Normal (18.5–24.9): 27/68 = (39.7%) Overweight (25–29.9): 12/68 = (17.7%) Obese (> 30): 23/68 = (33.8%) Mean = 27.5 ± 7.9
Patient demographics included in the study were separated into age, gender, race, and BMI.	

Table 2. Cystotomy repair results

	Barbed	Non Barbed
Laparoscopic Repair	3*	8
Open Repair	1¶	18
Robotic Repair	7*	4
Operative Time (min)	162.0 ±84.5	244.7 ±144.7
Time to Foley Removal (days)	17.1 ±12.4	14.5 ±7.2
Length of Stay (days)	3.5 ±3.9	6.1 ±5.4
Post Operative Fluroscopy	9	23
Post Operative Voiding Trial	1	2
Complications	3	8

Legend: *=p < .05; ¶=p < .01

The results display the setting of cystotomy repair and patient outcomes between barbed and non barbed suture.

Barbed suture was used for cystotomy repair in 11/68 (16.2%) patients and the mean age of this group was 42.2 ± 20.0 years. In the non-barbed suture group, the mean age was older at 54.0 ± 19.5 years. While the older mean age in the non-barbed suture group approached significance, age between suture groups was not a significant finding (p = .0725). The mean BMI in the barbed suture group was 33.6 ± 12.6 and was significantly higher than the non-barbed suture group (26.4 ± 6.1) (p = .0046). Additionally, there was not a significant gender difference between the two suture groups (x^2 = 0.3029).

Most of the patients had a previous surgical history 41/68 (60.3%). 21 patients had a history of open surgery and 27 patients had a previous surgery that was completed laparoscopically. Of the patients with a history of laparoscopic surgery, 9 were gynecologic related surgeries. 10 patients had a history of cesarean section. There was no statistically significant difference when comparing surgical history and type of suture used in subsequent cystotomy repair (x^2 = 0.1703). We explored the use of suture types for cystotomy repair relative to obstetric history. Of the female patients, 19/33 (57.6%) were previously pregnant. Three of the patients in which barbed suture was used were previously pregnant, however, the type of suture used was non-significant based on gravida status (Mann Whitney = 0.2113). Similarly, there was no difference between suture use and a birth history (Mann Whitney = 0.2801).

In our review, cystotomy repair was completed in a variety of settings. Because a majority of urinary tract injuries occur during gynecologic procedures, groups were categorized based on whether the primary procedure was gynecologic 13/41 (32.5%) or non-gynecologic 27/41 (67.5%). Of the gynecologic group, barbed suture was used in 3 patients. Of the non-gynecologic group, barbed suture was used in 8 patients. The type of suture selected for cystotomy repair relative to the procedure type was not significant (x^2 = 0.6010).

Groups were also categorized based on whether cystotomy repair was performed in a laparoscopic 11/41 (26.8%), robotic 11/41 (26.8%) or open 19/41 (46. 4%) setting. When barbed suture was used for cystotomy repair, it was most often utilized in a robotic setting 7/11 (63.6%) followed by laparoscopic 3/11 (27.3%) then open 1/11 (9.1%). The use of barbed suture relative to each mode of surgery was significant when compared to non-barbed suture use. A summary of these results are listed in Table 2.

There were 11 complications associated with cystotomy repair. Complications were defined as subsequent bladder conditions that developed after cystotomy repair that required additional follow up or treatment. The overall complication rate in our study was 0.27. Three were associated with barbed suture use but this was not statistically significant from the complication rate of non-barbed suture use (x^2 = 0.9842).

Discussion:

There are multiple challenges that make minimally invasive knot tying difficult skills to master. The loss of depth perception, the limited degree of movement, and loss of tactile feedback are obstacles that must be overcome to develop competency in a laparoscopic setting. Moreover, proficient knot tying in open

surgical experience does not translate to laparoscopic knot tying ability and requires consistent practice [7]. Robotic surgery recovers depth perception and increases the degree of operative movement, however, the loss of immediate feedback when suturing by hand in an open case often results in weaker knots or over-tightening leading to tissue ischemia [9, 12]. With barbed suture, knot tying is not necessary. This reduces the skill required to use it. The barbs of the suture self-anchor to provide consistent tissue apposition and eliminate the necessity of an additional hand to follow the thread (Fig. 2). Furthermore, knots introduce weak points in traditional suture. Without the need for knots in barbed suture, the risk of suture failure is decreased [13]. Ultimately, the technical aspects of traditional suture use with laparoscopic instruments are eliminated with barbed suture. As such, we would expect a greater use in a minimally invasive setting as compared to an open procedure. We saw a statistically significant use of barbed suture in laparoscopic vs open, robotic vs open, and laparoscopic vs robotic procedures over non barbed suture. This data supports the utility of barbed suture in a minimally invasive approach.

A significant portion of our study population was overweight or obese. Obesity is a rapidly growing problem especially in the United States and these patients tend to have more concurrent comorbidities [8]. In addition, operating on patients with an elevated BMI adds physical complexity to cases. To improve outcomes and quality of life, the least invasive approach should be offered regardless of BMI. With proper preparation and optimization of comorbidities, minimally invasive surgery is the safest approach with the lowest risk of complications [8, 14, 15]. Although more challenging in obese patients, an experienced anesthetic team, proper set up and entry can increase chances of a successful procedure. Unexpected complications like injury to the bladder may arise due to thick adhesions, limited visibility, and anatomical distortion [1]. Immediate repair can be done if an injury is recognized intraoperatively and typically, when an injury occurs during a laparoscopic procedure, the repair is completed in the same fashion to avoid subsequent risks of laparotomy [2, 3]. However, a traditional bladder repair requires precise suturing and knot tying in order to prevent long-term sequelae and achieving this laparoscopically is among the most difficult skill to master, requiring many hours of practice in order to gain proficiency. The knotless barbed suture has been proposed to make laparoscopic suturing easier and more efficient. Several in vivo studies have demonstrated faster closure times and reduction of difficulty with the use of barbed suture [12, 16]. Angioli et al. assessed barbed suture use in laparoscopic myomectomy and found a significant decrease in suturing time and blood loss in the barbed suture group [17]. Although we found no differences between total operative time, we did not record suturing time of the bladder repair. However, any measure to reduce time under anesthesia especially in obese patients with significantly altered respiratory physiology is paramount. We found a significantly higher BMI in the patients that had cystotomy repair utilizing barbed suture. We also found greater barbed suture utilization in a minimally invasive setting. Our study suggests that the advantages of barbed suture make it suitable or preferred in more challenging cases such as laparoscopic surgeries in obese patients.

Most of the patients in our study that underwent cystotomy repair had previous operations 41/68 (60.3%). A multitude of factors are considered before a patient undergoes an operation and usually the benefit of the procedure outweighs the risks of surgical intervention. An attempt to minimize these risks such as intraoperative complications should be made but can never be eliminated. A significant surgical

history, baseline comorbidities, chronic infections or inflammation, and complexity of the surgical case are some of the risk factors for complications [5, 18]. Complications are an unfortunate part of any surgical procedure. The most common during cystotomy repair include urinary leak, urinary tract infection, urinary retention, and stone formation. In our study, 16.2% of patients developed a complication. Although this seems high, our definition of complication was broad and may not have been directly related to the type of suture used during the bladder repair. Also, there have been limited studies that have evaluated the type of suture used in bladder repair relative to complications. In our study, the number of complications associated with barbed suture was not significantly different than non-barbed suture, the standard of care. Similarly, a recent case series utilizing barbed suture for cystotomy repair did not result in additional complications [2].

This study has several limitations. With any study relying on electronic medical records, coding discrepancies could exist causing misclassification with data collection. Also, with limited post-operative follow up, it is difficult to discern whether the surgical outcomes were long lasting. In our practice, we typically follow up with the patients 4–6 weeks after surgery and voiding cystometrogram or cystoscopy are not routinely performed. This database may not have included all observable patient characteristics that could confound the association between the use of barbed suture and patient outcome. Also, it could be argued that selection bias exists on account of a disproportionate number of patients were overweight or obese. Although this might account for some of the results seen within our study, the patient demographics within the state of West Virginia do not demonstrate substantial diversity with regards to weight. Furthermore, it is possible that non-modifiable patient factors could explain our observed results. Finally, since all the data was collected from a single academic, tertiary care hospital, this may limit the generalizability to non-academic community hospitals.

Conclusion:

Barbed suture is not inferior to standard braided suture for cystotomy repair and does not cause an increase in complication rate. The use of barbed suture removes the tedious process of laparoscopic and robotic knot tying. Therefore, barbed suture offers a practical alternative to facilitate cystotomy repair in minimally invasive surgery, especially in patients with a high BMI. This study contributes to existing literature on treating urologic complications with a minimally invasive surgical approach. Further research is warranted to determine what, if any, long-term effects this technique will have.

Abbreviations

WVU
West Virginia University
BMI
Body mass index

Declarations

Ethics approval and consent to participate: This is a retrospective cohort study using the medical records from West Virginia Medicine healthcare system. This Study was approved by the West Virginia University Institutional Review Board (approval number 1909723019).

Consent for publication: Not Applicable

Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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Authors' contributions: Authors RS and OD conceived and designed the study. Data collection was performed by author AS. Authors RS, AS, MV performed data analysis and interpretation. Authors RS, SZ, OG, and CG were surgeons and responsible for patient recruitment. MV performed the statistical analysis. Authors RS, AS, CG, OD were involved in manuscript preparation with input from all authors.

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Figures

Bladder Injury	Description	Required Repair
Grade 1	Contusion, intramural hematoma, partial laceration	Placement of Foley catheter for 7-14 days post op
Grade 2	Extraperitoneal bladder wall laceration <2cm	
Grade 3	Extraperitoneal (>2cm) or intraperitoneal (<2cm) bladder wall laceration	Immediate intraoperative repair
Grade 4	Intraperitoneal bladder wall laceration 2cm or greater	
Grade 5	Intraperitoneal or extraperitoneal bladder wall laceration extending into the bladder neck or trigone	

Figure 1

Bladder injury classification

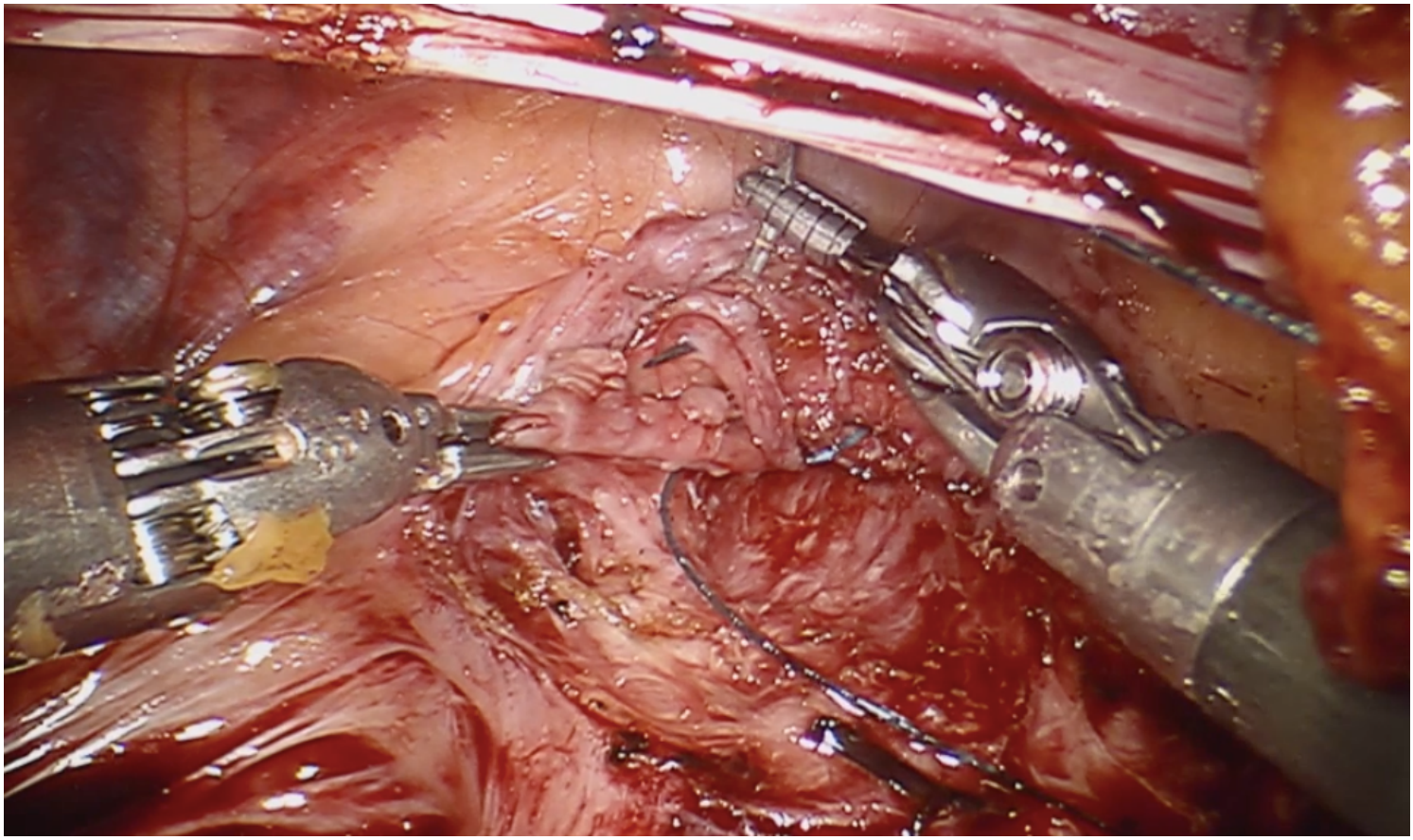

Figure 2

Approximation of the edges of the bladder using the barbed suture

Supplementary Files

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