Laparoscopic Ventral Hernia Repair Postoperative Complications in End Stage Renal Disease Patients

Steven D. Gurien, MD, Paul Chung, MD, Colleen P. Nofi, DO, Gene F. Coppa, MD, Gainosuke Sugiyama, MD

ABSTRACT

Background: The prevalence of patients with end stage renal disease (ESRD) requiring general surgical procedures is increasing. Our aim was to explore the effect of ESRD on patients undergoing elective laparoscopic ventral hernia repair.

Methods: The American College of Surgeons National Surgical Quality Improvement Program (2010–2015) database was used to identify patients who underwent elective laparoscopic ventral hernia repair. Multivariable analysis was performed adjusting for risk variables including age, gender, race, comorbidity status, body mass index ≥ 35, and presence of ESRD.

Results: A total of 8,789 patients undergoing elective laparoscopic ventral hernia repair were identified. Sixty-four patients (0.73%) had ESRD. ESRD was identified as an independent risk factor for postoperative pneumonia (odds ratio [OR] 6.91, p = 0.00363), sepsis (OR 18.58, p = 0.000286), and length of stay (IRR 1.63, 95% confidence interval 1.19 – 2.27, p = 0.0036).

Conclusions: ESRD patients undergoing elective laparoscopic ventral hernia repair had an increased risk of postoperative pneumonia, sepsis, and length of stay. Clinicians should be cognizant of these risks when performing elective operations on ESRD patients.

Key Words: ACS NSQIP, Elective, ESRD, Laparoscopic ventral hernia repair.

INTRODUCTION

End stage renal disease (ESRD) is a prevalent disease in the United States, with over 131,000 new cases reported in 2018 and a prevalence of over 785,000.1 ESRD can be caused by many etiologies with the two most common causes in the U.S. being diabetes and long standing hypertension.1 The number of ESRD patients continues to rise yearly by about 20,000 patients.2 As the number of patients with ESRD rises, the number of common surgical procedures performed on ESRD patients will simultaneously increase, including laparoscopic ventral hernia repairs.

Ventral hernia repair is a frequently performed general surgery procedure. There is an estimated 400,000 – 600,000 incisional hernia repairs occurring each year in the U.S.2 Ventral hernias can either be primary hernias or secondary to previous abdominal surgery or trauma.3 Incisional hernias are a common complication of open abdominal surgery with rates of 10% – 32%.4,5 They can be repaired by open approach or laparoscopically. The laparoscopic approach for ventral hernias has proven to have fewer wound complications than the open approach, as well as a decreased length of hospital stay.6

Given the high incidence of ventral hernias and the increasing prevalence of ESRD, it is likely that general surgeons will encounter a growing number of these patients in their practice. Our objective was to use The American College of Surgeons National Surgery Quality Improvement Project (ACS NSQIP) database in order to determine the risks involved for ESRD patients who underwent elective laparoscopic ventral hernia repair. We found that patients with ESRD have an increased risk of postoperative pneumonia and sepsis, as well as increased postoperative length of stay (LOS) after elective laparoscopic ventral hernia repair. Identifying and understanding the associated risks can help to better guide surgeons in their judgement, decisions, and advice to ESRD patients undergoing nonemergency laparoscopic ventral hernia repair.

METHODS

The ACS NSQIP participant user files from January 1, 2010 – December 31, 2015 were utilized. Adult patients (≥18 years...
of age) who underwent elective laparoscopic repair of an initial reducible ventral hernia (Current Procedural Terminology code 49652) were identified. These patients had a postoperative diagnosis of nonobstructed, nongangrenous ventral hernia (ICD9 5530.2, 553.20, 553.21, 553.29) who were admitted from home and underwent repair by a general surgeon under general anesthesia. Cases that had a postoperative wound class of III or IV were excluded. Cases with missing gender, body mass index (BMI), functional status, American Society of Anesthesiologists classification (ASA), and postoperative LOS data were excluded, and an unknown factor for missing race data was created. There were 8,789 total cases that met inclusion criteria.

Risk variables included age, gender, race, BMI ≥35 kg/m², functional status, ASA class, and ESRD status. ESRD was defined as patients requiring treatment with peritoneal dialysis, hemodialysis, hemofiltration, hemodiafiltration, or ultrafiltration within two weeks prior to surgery. Outcome variables of interest included postoperative superficial surgical site infection (SSI), deep SSI, organ-space SSI, dehiscence, pneumonia, reintubation, failure to wean from ventilator, pulmonary embolism, cardiac arrest, myocardial infarct, bleeding, deep vein thrombosis, sepsis, septic shock, return to the operating room, and death. Univariate analysis was performed comparing ESRD patients versus non-ESRD patients (control). Student’s t test or Wilcoxon Rank Sum test was used for continuous variables while χ² test or Fisher’s exact test was used for categorical variables where appropriate. Multivariable logistic regression was performed adjusting for all risk variables. Postoperative LOS was also analyzed using negative binomial regression adjusting for all risk variables. Analysis was performed with the R statistical language version 3.50.1. A two-tailed P value of < .05 was considered statistically significant.

**RESULTS**

Table 1 shows the patients’ characteristic data. Of the 8,789 cases that met inclusion/exclusion criteria, 64
patients (0.73%) had ESRD. On univariate analysis, ESRD patients tended to be older (median (standard deviation [SD]): 62 (± 14.0) vs 54 (± 13.6) years, \( p = .0147 \)), male (60.9% vs 43.6%, \( P < .0080 \)), and have a higher ASA class (65.6% vs 36.2% class III, \( p = < .0001 \)). Likewise, comparison of outcomes within 30 days revealed that patients with ESRD had higher rates of dehiscence (1.6% vs 0.1%, \( P = .0359 \)), postoperative pneumonia (6.3% vs 0.4%, \( P = .0002 \)), bleeding requiring transfusions (3.2% vs 0.4%, \( P = .0238 \)), sepsis (3.2% vs 0.3%, \( P = .0175 \)), and return to the operating room (4.7% vs 1.1%, \( P = .0371 \)). Results are shown in full in Table 2.

Logistic multivariable regression analysis, adjusting for age, gender, race, BMI \( \geq 35 \), functional status, ASA classification, and ESRD status demonstrated that ESRD was an independent risk factor for postoperative pneumonia (OR 7.01, 95% confidence interval [CI] 1.91 – 25.68, \( P = .0033 \)) and postoperative sepsis (OR 18.47, 95% CI 3.82 – 89.39, \( P = .0003 \)). Dehiscence, bleeding, and return to the operating room were not found to be significant on multivariable analysis. Results are shown in full in Table 3. Postoperative LOS was analyzed using negative binomial regression and again adjusting for age, gender, race, BMI \( \geq 35 \), functional status, ASA classification, and ESRD status. Incidence rate ratio was significant for ESRD as an independent risk factor for increased postoperative LOS (incidence rate ratio 1.63, 95% CI 1.19 – 2.27, \( P = .0036 \)). Full results are shown in Table 4.

**DISCUSSION**

We performed an observational study which compared the outcomes of elective laparoscopic ventral hernia repairs between patients with and without ESRD. By using the ACS NSQIP database, we found an increase in postoperative complications in the ESRD patients. However, despite these increased postoperative complications and LOS, mortality was not significantly increased in the ESRD patient group. Specifically, on univariate analysis, ESRD patients undergoing laparoscopic ventral hernia repair had increased rates of postoperative pneumonia, sepsis, dehiscence, bleeding requiring transfusion, and return to the operating room when compared to patients without ESRD. Using multivariate analysis and negative binomial

| Table 2. Univariate Analysis of 30-Day Postoperative Outcomes |
|---------------------------------------------------------------|
| **30-Day Postoperative Outcomes**                             | **Control** (n = 8,725) | **End Stage Renal Disease** (n = 64) | **p-Value** |
| Postoperative Length of Stay, median (standard deviation), days | 0 (2.5)                 | 1 (8.6)                             | 0.1608     |
| Superficial Wound Infection (%)                               | 49 (0.6)                | 0 (0.0)                             | 1.0        |
| Deep Wound Infection (%)                                     | 12 (0.1)                | 0 (0.0)                             | 1.0        |
| Organ Space Infection (%)                                    | 20 (0.2)                | 1 (1.6)                             | 0.1424     |
| Dehiscence (%)                                                | 4 (0.1)                 | 1 (1.6)                             | 0.0359     |
| Pneumonia (%)                                                 | 36 (0.4)                | 4 (6.3)                             | 0.0002     |
| Reintubation (%)                                              | 26 (0.3)                | 1 (1.6)                             | 0.1793     |
| Failure to Wean from Ventilator (%)                           | 17 (0.2)                | 1 (1.6)                             | 0.1234     |
| Pulmonary Embolism (%)                                        | 12 (0.1)                | 0 (0.0)                             | 1.0        |
| Deep Vein Thrombosis (%)                                      | 19 (0.2)                | 0 (0.0)                             | 1.0        |
| Cerebrovascular Accident (%)                                  | 5 (0.1)                 | 0 (0.0)                             | 1.0        |
| Myocardial Infarct (%)                                        | 14 (0.2)                | 0 (0.0)                             | 1.0        |
| Cardiac Arrest (%)                                            | 7 (0.1)                 | 0 (0.0)                             | 1.0        |
| Bleeding Requiring Transfusions (%)                           | 31 (0.4)                | 2 (3.2)                             | 0.0238     |
| Sepsis (%)                                                    | 26 (0.3)                | 2 (3.2)                             | 0.0175     |
| Septic Shock (%)                                              | 13 (0.2)                | 0 (0.0)                             | 1.0        |
| Return to Operating Room (%)                                  | 98 (1.1)                | 3 (4.7)                             | 0.0371     |
| Death (%)                                                     | 16 (0.2)                | 0 (0.0)                             | 1.0        |
regression, we found a higher rate of postoperative pneumonia, sepsis, and LOS in the ESRD group.

ESRD patients have previously been described as higher risk patients for postoperative complications in many surgical disciplines and can be seen in our cohort as having a higher American Society of Anesthesiologists classification. For example, ESRD patients who underwent elective endovascular repair of abdominal aortic aneurysms had increased hospital length of stay, higher hospital mortality rate, higher 30 day mortality rate, and higher one year mortality rate. In elective major vascular surgical procedures, ESRD patients had higher rates of surgical site infection, unplanned intubation, and reoperation within 30 days when compared to non-ESRD patients. In hip and knee replacements, stages III-V chronic kidney disease had a greater hazard ratio as a risk factor for mortality than congestive heart failure, coronary artery disease, and diabetes. In common general surgeries (including colectomy, appendectomy, cholecystectomy, and ventral hernia repair), ESRD patients had an increased 30 day mortality rate, increased rates of infectious complications, and increased risk of returning to the operating room. After a complication from a general surgical procedure, ESRD patients had a higher mortality rate than individuals with the same postoperative complications but who did not have ESRD.

In our study, we found increased rates of postoperative pneumonia, sepsis, dehiscence, bleeding requiring transfusion, and return to the operating room when compared to patients without ESRD on univariate analysis. Using multivariate analysis and negative binomial regression, there was a higher rate of postoperative pneumonia, sepsis, and LOS in the ESRD group.

Alterations to the immune system of ESRD patients is complex and involves multiple aspects that lead to immune dysfunction. Impaired immunological function helps account for infection as the second leading cause of mortality in this population, with cardiovascular disease accounting for the number one cause of mortality. The increase in postoperative pneumonia and sepsis in ESRD patients in our study may be related to this underlying immune dysfunction described in ESRD patients resulting in immunodepression and increased risk for infectious complications. Similarly, it has previously been described that patients undergoing laparoscopic cholecystectomy had significantly higher rates of postoperative pneumonia if they had ESRD (2.3 vs 0.4%), as well as higher rates of sepsis (3.1 vs 0.4%). Other studies have shown similar results of increased postoperative infectious complications in ESRD patients, including sepsis, septic shock, urinary tract infections, and postoperative pneumonia.

### Table 3.
Multivariable Logistic Regression Analysis Showing the Effects of End Stage Renal Disease on Outcomes

| Risk Variable                  | Odds Ratio | 95% Confidence Interval | p-Value |
|-------------------------------|------------|-------------------------|---------|
| Superficial Wound Infection   | 0.00       | — †                     | 0.8959  |
| Deep Wound Infection         | 0.00       | — †                     | 0.9448  |
| Organ Space Infection        | 6.39       | (0.65 – 63.35)          | 0.1129  |
| Dehiscence                    | 3.82       | (0.22 – 66.03)          | 0.3562  |
| Pneumonia                     | 7.01       | (1.91 – 25.68)          | 0.0033  |
| Reintubation                  | 0.97       | (0.11 – 8.36)           | 0.9781  |
| Failure to Wean from Ventilator| 2.78      | (0.29 – 2.63)           | 0.3716  |
| Pulmonary Embolism            | 0.00       | — †                     | 0.9378  |
| Deep Venous Thrombosis        | 0.00       | — †                     | 0.9286  |
| Cerebrovascular Accident      | 0.00       | — †                     | 0.9475  |
| Myocardial Infarction         | 0.00       | — †                     | 0.9503  |
| Cardiac Arrest                | 0.00       | — †                     | 0.9552  |
| Bleeding Requiring Transfusions| 3.67      | (0.72 – 18.66)          | 0.1177  |
| Sepsis                        | 18.47      | (3.82 – 89.39)          | 0.0003  |
| Septic Shock                  | 0.00       | — †                     | 0.9190  |
| Return to Operating Room      | 1.92       | (0.53 – 6.95)           | 0.3225  |
| Death                         | 0.00       | (0.65 – 2.33)           | 0.9043  |

†Confidence interval spanning 0 - 1.
infections, wound infections, and pneumonia after general surgery and major abdominal surgery, when compared to non-ESRD patients.\textsuperscript{10,19,20} Mortality from sepsis has been found to be 100-fold higher in ESRD patients than in the general population.\textsuperscript{21}

While comorbidities may increase perioperative risks including ESRD as described, there are no universally accepted guidelines on when to perform elective laparoscopic ventral hernia repair. The Society of American Gastrointestinal Endoscopic Surgeons guidelines for example, note few special considerations where laparoscopic ventral hernia repair may be contraindicated, such as loss of domain, presence of abdominal skin graft, active enterocutaneous fistula, the need to remove previously placed prosthetic mesh, or large abdominal wall defects.\textsuperscript{22} However, pre-existing conditions and potentially associated complications are not discussed.

There is no absolute contraindication for the use of mesh in the ESRD patient population.\textsuperscript{23} Martinez-Mier et al. reported a single wound infection (not specified whether related to mesh) among 58 hernia repairs in the setting of perioperative peritoneal dialysis. Due to their reported 12\% hernia recurrence in hernioplasties performed without mesh and low incidence of infection, they recommended use of mesh in this setting.\textsuperscript{24} Two additional studies found no evidence of mesh infection after 26 and 20 elective hernia repairs.\textsuperscript{25, 26}

Additionally, the surgeon may encounter platelet dysfunction in ESRD patients, which can be seen in patients who are uremic. This dysfunction is caused by impaired platelet adhesiveness, as well as abnormal endothelial interaction.\textsuperscript{27} Furthermore, many ESRD patients take antiplatelet agents, as they have been shown to reduce major cardiovascular events by 15\% and decrease access failure events by 48\%.\textsuperscript{28} Platelet dysfunction can lead to increased bleeding during and after surgical procedures resulting in blood transfusions, hematomas, and reoperations. In our study, ESRD patients had an increased risk of perioperative bleeding requiring transfusions on univariate analysis. This is consistent with previous published data showing increased perioperative bleeding complications in the ESRD population.\textsuperscript{29}

This study was performed using the ACS NSQIP database and therefore has several limitations. The ACS NSQIP database is limited to only the data points which are collected by individual hospitals and submitted to the national database. Charts are not able to be reviewed in order to obtain more information and our analyses regarding patients’ return to the operating room may lack more detailed information as a result. In addition, the data that

| Risk Variables                        | Incidence Rate Ratio | 95\% Confidence Interval | \(p\)-Value |
|--------------------------------------|----------------------|--------------------------|-------------|
| Age                                  | 1.02                 | 1.01 – 1.02              | < 0.0001    |
| Male Gender                          | 0.73                 | 0.69 – 0.78              | < 0.0001    |
| Race                                 |                      |                          |             |
| African American                     | 1.28                 | 1.16 – 1.41              | < 0.0001    |
| American Indian or Alaska Native     | 1.52                 | 1.05 – 2.24              | 0.0345      |
| Asian or Pacific Islander            | 0.89                 | 0.64 – 1.24              | 0.4816      |
| Unknown                              | 0.97                 | 0.86 – 1.10              | 0.6770      |
| Body Mass Index > 35                 | 1.02                 | 0.95 – 1.10              | 0.5960      |
| Functional Status                    |                      |                          |             |
| Partially Dependent                  | 2.38                 | 1.62 – 3.60              | < 0.0001    |
| Totally Dependent                   | 2.45                 | 0.82 – 10.24             | 0.1478      |
| American Society of Anesthesiologists Class |        |                          |             |
| Class II                             | 1.61                 | 1.38 – 1.88              | < 0.0001    |
| Class III                            | 2.76                 | 2.35 – 3.25              | < 0.0001    |
| Class IV                             | 3.89                 | 2.98 – 5.11              | < 0.0001    |
| End Stage Renal Disease              | 1.63                 | 1.19 – 2.27              | 0.0036      |
is collected and sent by each individual hospital does not include all of their surgical patients, but rather a portion of surgical patients from each hospital that participates. These limitations; however, are true of all studies utilizing ACS NSQIP abstracted data. The host of different training mechanisms for surgical clinical reviewers, quality audits, and other safeguards employed by ACS NSQIP help to ensure the highest quality of data that can be reliably utilized for such quality improvement-driven analyses.

ACS NSQIP data also carries the advantage of representing a national pool of patients, including a total of 3,636,854 cases submitted by 2,502 hospitals between January 1, 2010 and December 31, 2015, of which 8,789 cases met inclusion criteria and were utilized in our study. Since the ACS NSQIP database is comprised of a wide distribution of patients nationally, there are patients from a wide array of cultures and ethnicities, as well as from urban areas, rural areas, teaching hospitals and community hospitals. This makes our results generalizable to the general population.

CONCLUSION

In this observational study, we found that in the setting of elective laparoscopic ventral hernia repair, patients with ESRD have an increased risk of postoperative pneumonia and sepsis, as well as increased postoperative LOS. Clinicians should consider these risks when evaluating expected outcomes and performing elective operations such as ventral hernia repair on ESRD patients.

References:

1. United States Renal Data System. USRDS 2020 Annual Data Report. Chapter 1: Incidence, Prevalence, Patient Characteristics, and Treatment Modalities. https://adr.usrds.org/2020/end-stage-renal-disease/1-incidence-prevalence-patient-characteristics-and-treatment-modalities. Accessed December 6, 2021.

2. Donkor C, Gonzalez A, Gallas MR, Helbig M, Weinstein C, Rodriguez J. Current perspectives in robotic hernia repair. Robot Surg. 2017;4:57–67.

3. Trujillo CN, Fowler A, Al-Temimi MH, Ali A, Johna S, Tessier D. Complex ventral hernias: a review of past to present. Perm J. 2018;22:17–015.

4. Mudge M, Hughes LE. Incisional hernia: a 10 year prospective study of incidence and attitudes. Br J Surg. 1985;72(1):70–71.

5. Kroese LF, Sneiders D, Kleinrensink GJ, Muyssoms F, Lange JF. Comparing different modalities for the diagnosis of incisional hernia: a systematic review. Hernia. 2018;22(2):229–242.

6. Sauerland S, Walgenbach M, Habermalz B, Seiler CM, Miserez M. Laparoscopic versus open surgical techniques for ventral or incisional hernia repair. Cochrane Database Syst Rev. 2011(3).

7. Komshian S, Farber A, Patel VI, et al. Patients with end-stage renal disease have poor outcomes after endovascular abdominal aortic aneurysm repair. J Vasc Surg. 2019;69(2):405–413.

8. Gajdos C, Hawn MT, Kile D, et al. The risk of major elective vascular surgical procedures in patients with end-stage renal disease. Ann Surg. 2013;257(4):766–773.

9. Jämsä P, Jämsen E, Huhtala H, Eskelinen A, Oksala N. Moderate to severe renal insufficiency is associated with high mortality after hip and knee replacement. Clin Orthop Relat Res. 2018;476(6):1284–1292.

10. Brakoniecki K, Tam S, Chung P, Smith M, Alfonso A, Sugiyama G. Mortality in patients with end-stage renal disease and the risk of returning to the operating room after common General Surgery procedures. Am J Surg. 2017;213(2):395–398.

11. Gajdos C, Hawn MT, Kile D, Robinson TN, Henderson WG. Risk of major nonemergent inpatient general surgical procedures in patients on long-term dialysis. JAMA Surg. 2013;148(2):137–143.

12. Tam SF, Au JT, Chung PJ, Duncan A, Alfonso AE, Sugiyama G. Is it time to rethink our management of dialysis patients undergoing elective ventral hernia repair? Analysis of the ACS NSQIP database. Hernia. 2015;19(5):827–833.

13. Anding K, Gross P, Rost JM, Allgäuer D, Jacobs E. The influence of urosepsis and haemodialysis on neutrophil phagocytosis and antimicrobial killing. Nephrol Dial Transplant. 2003;18(10):2067–2073.

14. Eleftheriadis T, Antoniadi G, Liakopoulos V, Kartsiou C, Stefanidis I. Disturbances of acquired immunity in hemodialysis patients. Semin Dial. 2007;20(5):440–451.

15. Kato S, Chmielewski M, Honda H, et al. Aspects of immune dysfunction in end-stage renal disease. Clin Am Soc Nephrol. 2008;3(5):1526–1533.

16. Camins BC. Prevention and treatment of hemodialysis-related bloodstream infections. Semin Dial. 2013;26(4):476–481.

17. Jaber BL. Bacterial infections in hemodialysis patients: pathogenesis and prevention. Kidney Int. 2005;67(6):2508–2519.

18. Rao A, Polanco A, Chin E, Divino CM, Qiu S, Nguyen SQ. Safety of elective laparoscopic cholecystectomy in patients on dialysis: an analysis of the ACS NSQIP database. Surg Endosc. 2014;28(7):2208–2212.

19. Schneider CR, Cobb W, Patel S, Cull D, Anna C, Roettger R. Elective surgery in patients with end stage renal disease: what’s the risk? Am Surg. 2009;75(9):790–793.
20. Cloyd JM, Ma Y, Morton JM, Tamura MK, Poultsides GA, Visser BC. Does chronic kidney disease affect outcomes after major abdominal surgery? Results from the National Surgical Quality Improvement Program. *J Gastrointest Surg*. 2014;18(3):605–612.

21. Sarnak MJ, Jaber BL. Mortality caused by sepsis in patients with end-stage renal disease compared with the general population. *Kidney Int*. 2000;58(4):1758–1764.

22. Earle D, Roth JS, Saber A, et al. SAGES guidelines for laparoscopic ventral hernia repair. *Surg Endosc*. 2016;30(8):3163–3183.

23. Lee MB, Bargman JM. Myths in peritoneal dialysis. *Curr Opin Nephrol Hypertens*. 2016;25(6):602–608.

24. Martínez-Mier G, Garcia-Almazan E, Reyes-Devesa HE, et al. Abdominal wall hernias in end-stage renal disease patients on peritoneal dialysis. *Perit Dial Int*. 2008;28(4):391–396.

25. Shah H, Chu M, Bargman JM. Perioperative management of peritoneal dialysis patients undergoing hernia surgery without the use of interim hemodialysis. *Perit Dial Int*. 2006;26(6):684–687.

26. Sodo M, Bracale U, Argentino G, et al. Simultaneous abdominal wall defect repair and Tenckhoff catheter placement in candidates for peritoneal dialysis. *J Nephrol*. 2016;29(5):699–702.

27. Kaw D, Malhotra D. Platelet dysfunction and end-stage renal disease. *Semin Dial*. 2006;19(6):317–322.

28. Sohal AS, Gangji AS, Crowther MA, Treleaven D. Uremic bleeding: pathophysiology and clinical risk factors. *Thromb Res*. 2006;118(3):417–422.

29. Clark NP, Douketis JD, Hasselblad V, et al. Predictors of perioperative major bleeding in patients who interrupt warfarin for an elective surgery or procedure: Analysis of the BRIDGE trial. *Am Heart J*. 2018;195:108–114.