ORIGINAL RESEARCH

Association of Hemoglobin A_{1c} With Outcomes Following Urologic Oncology Procedures in Veterans

Justin Lee, MD[a]; Kathleen Escoto, MPH[b]; David Nakach, MS[c]; Pietra Greenberg, MD[b]; Prabhjot Mundi, MD[a]; Tito Fojo, MD[a]; Izak Faiena, MD, MSCR[b]

Background: Diabetes mellitus (DM) is a known risk factor for complications following oncologic surgeries. Hemoglobin A_{1c} (HbA_{1c}) reflects average glucose levels over the past 90 days. No large-scale study to date has evaluated the association between HbA_{1c} levels and outcomes in urologic oncologic surgeries.

Methods: The US Department of Veterans Affairs Informatics and Computing Infrastructure (VINCI) database was queried for cystectomy, prostatectomy, and nephrectomy codes performed for prostate, bladder, or kidney cancer, respectively, from 2001 to 2023. HbA_{1c} values within 90 days of surgery were queried and patients were categorized by HbA_{1c} level; $HbA_{1c} < 5.7\%$ or patients with no documented DM represented the reference group. Patients without DM and HbA_{1c} data were excluded. Complications, readmissions, and postoperative deaths within 30 and 90 days were evaluated. Multivariable logistic regression models were adjusted for age, sex, race/ethnicity, body mass index, smoking status, and Charlson Comorbidity Index.

Results: Among 97,498 patients, 41,631 had perioperative HbA_{1c} data. Elevated HbA_{1c} was significantly associated with increased 30- and 90-day complication rates after prostatectomy (odds ratio [OR], 1.17 [95% CI, 1.04-1.32] and 1.27 [95% CI, 1.14-1.43], respectively) and nephrectomy (OR, 1.10 [95% CI, 1.03-1.18] and 1.19 [95% CI, 1.04-1.36], respectively). Additionally, $HbA_{1c} \geq 9.0\%$ was strongly linked to death 30 days following prostatectomy (OR, 2.14 [95% CI, 1.08-4.26]).

Conclusions: Elevated perioperative HbA_{1c} was significantly associated with 30-day and 90-day complications for prostatectomy and nephrectomy in the VINCI database after controlling for several clinical factors. These findings support the need for prospective studies to assess whether lowering HbA_{1c} values perioperatively may reduce complications in these patients.

This article has been adjusted for space considerations. The complete version, including supplementary tables, can be found online.

Author affiliations can be found at the end of this article.
Correspondence: Izak Faiena (if2274@cumc.columbia.edu)

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Diabetes mellitus (DM) is a well-known risk factor for postoperative complications, including infections and poor wound healing.[1] Hemoglobin A_{1c} (HbA_{1c}) reflects a patient's mean glucose level over the past 90 days. The American Diabetes Association recommends using HbA_{1c} to monitor glycemic control.

Several meta-analyses and systematic reviews have demonstrated that elevated preoperative HbA_{1c} levels are associated with higher rates of postoperative complications.[2-5] An association between poor glycemic control and perioperative complications has been reported in cardiac, bariatric, abdominal, and orthopedic surgeries. In 1 prospective study, patients with $HbA_{1c} \geq 7\%$ had significantly higher incidences of postoperative infection and wound problems compared with patients with $HbA_{1c} < 7\%$.[6] In another study of 1775 patients with DM who underwent noncardiac surgery, patients with $HbA_{1c} > 8\%$ had significantly longer hospital stays.[7]

The relationship between HbA_{1c} and postoperative complications following urologic procedures, specifically oncologic surgeries, has not been as well researched. One study reported that uncontrolled preoperative DM was associated with complications following cystectomy.[8] However, this study did not evaluate HbA_{1c} levels as a marker. Another study reported an association between HbA_{1c} and infection following penile prosthetic implants, with an HbA_{1c} cutoff of 8.5% predicting increased risk of infection.[9] Better understanding the association between HbA_{1c} and postoperative complications following urologic oncology procedures may allow for better perioperative planning and improving clinical outcomes.

In this study, we examined the relationship between perioperative HbA_{1c} levels and postoperative outcomes (complications, readmission, and death) in patients undergoing urologic oncology procedures (cystectomy, prostatectomy, and nephrectomy), while controlling for recognized clinical risk factors.

METHODS

Data were compiled using the US Department of Veterans Affairs (VA) Corporate Data Warehouse (CDW) structured datasets within the VA Informatics and Computing Infrastructure (VINCI). The data in the VA CDW were aggregated from the VA electronic health record and curated for extraction and analysis.

The study examined veterans treated at any Veterans Health Administration facility from January 2000 to February 2024. Included patients had a diagnosis of prostate, bladder, or kidney cancer and ≥ 1 genitourinary surgery (cystectomy, prostatectomy, or nephrectomy) identified in the VA CDW using the ninth and 10th revisions of the *International Classification of Diseases* (*ICD*) codes. Demographic (age, sex, race, and ethnicity) and clinical data (body mass index, smoking status, and Charlson Comorbidity Index) were collected. HbA_{1c} values at multiple time points within 90 days pre- and postsurgery were retrieved using

TABLE 1. Baseline Characteristics of Cystectomy Surgery Patients

		Hemoglobin A_{1c} levels				
	Overall	**< 5.7%[a]**	**5.7%-6.4%**	**6.5%-8.9%**	**≥ 9.0%**	***P* value[b]**
Total, No.	8030	6351	526	994	164	
Age, mean (SD), y	68.2 (9.2)	67.7 (9.4)	70.2 (8.5)	69.9 (8.2)	67.7 (8.0)	
Male sex, No. (%)	7929 (98.7)	6260 (98.6)	517 (98.3)	989 (99.5)	163 (99.4)	.07
Race, No. (%)						.04
White	6144 (76.5)	4827 (76.0)	407 (77.4)	785 (78.6)	125 (76.2)	
Black	823 (10.3)	639 (10.1)	67 (12.7)	97 (9.8)	20 (12.2)	
Asian	20 (0.3)	14 (0.2)	2 (0.4)	3 (0.3)	1 (0.6)	
American Indian	37 (0.5)	28 (0.4)	2 (0.4)	5 (0.5)	2 (1.2)	
Native Hawaiian	52 (0.7)	39 (0.6)	3 (0.6)	10 (1.0)	0 (0)	
Unknown	959 (11.9)	804 (12.7)	45 (0.6)	94 (9.5)	16 (9.8)	
Ethnicity, No. (%)						< .001
Hispanic or Latino	233 (2.9)	159 (2.5)	20 (3.8)	42 (4.2)	12 (7.3)	
Not Hispanic or Latino	7030 (87.5)	5530 (87.0)	473 (89.2)	890 (89.5)	137 (83.5)	
Unknown	772 (9.6)	662 (10.4)	33 (6.3)	62 (6.3)	15 (9.2)	
Body mass index, No. (%)						< .001
< 18.5	911 (11.3)	831 (91.2)	27 (2.9)	45 (4.9)	8 (0.9)	
18.5-24.9	3310 (41.2)	2738 (82.7)	189 (5.7)	332 (10.0)	51 (1.5)	
25.0-29.9	2300 (28.6)	1752 (76.2)	152 (6.6)	342 (14.9)	54 (2.4)	
30.0-34.9	1005 (12.5)	697 (69.4)	98 (9.8)	177 (17.6)	33 (3.3)	
≥ 35.0	509 (6.3)	333 (65.4)	60 (11.8)	98 (19.3)	18 (3.5)	
Tobacco use, No. (%)	4542 (56.5)	3609 (56.8)	306 (58.2)	530 (53.3)	97 (59.2)	.14
Charlson Comorbidity Index, No. (%)						< .001
1-2	118 (1.5)	1124 (96.6)	2 (0.4)	1 (0.1)	1 (0.6)	
3-4	1374 (17.1)	1240 (19.5)	43 (8.2)	80 (8.0)	11 (6.7)	
≥ 5	6538 (81.4)	4992 (78.7)	481 (91.4)	913 (91.8)	152 (92.7)	

[a]Includes patients without diabetes.
[b]Calculated using χ^2 tests with $P < .05$ considered statistically significant.

Logical Observation Identifiers, Names, and Codes (LOINC), a widely used coding system for laboratory tests (Supplementary Table 1). Outcomes data were extracted including death date, hospital readmission, and different types of complications first diagnosed within 30 or 90 days postsurgery based on *ICD* diagnostic codes (Supplementary Table 2). Patients with missing HbA_{1c} or DM data were excluded.

Statistical Analysis

The primary outcome variables included 30-day and 90-day complications, readmission, and death. The predictor variable was HbA_{1c} level within 90 days of the procedure, which was categorized into 4 groups. The reference category was HbA_{1c} < 5.7% and/or no history of DM. The next category fit the prediabetes (impaired glucose tolerance) definition, with HbA_{1c} between 5.7% and 6.4%, and the last 2 categories were HbA_{1c} values 6.5% to 8.9% and ≥ 9.0% to reflect uncontrolled DM. Associations between the different HbA_{1c} level groupings and other variables are reported with χ^2 tests. The final multivariable logistic regression models included several covariates including demographic data (age, sex, race, and ethnicity) and clinical data (body mass index, smoking status, and Charlson Comorbidity Index). Results are presented as odds ratios (ORs) and 95% CIs with a statistical significance threshold of $P < .05$. Statistical analyses were performed using Stata version 14.1.

RESULTS

A total of 106,740 veterans who underwent cystectomy, prostatectomy, or nephrectomy from 2001 to 2023 were identified in VINCI. After excluding patients without demographic or clinical variables, 97,498 patients were included in our final cohort. The most common procedure was prostatectomy (n = 59,316). Most of the patients were male (99.1%) and White (67.3%) (Tables 1, 2, and 3).

HbA_{1c} values within 90 days of surgery were available in 42.2% of patients with a mean HbA_{1c} value of 6.5% (Table 4). The prostatectomy group had the lowest proportion of patients with available HbA_{1c} data (38.4%) but the highest proportion in the reference category (82.5%).

Multivariable logistic regression models incorporating categorical HbA_{1c} values and other demographic and clinical variables were developed to predict all 30-day and 90-day outcomes

TABLE 2. Baseline Characteristics of Prostatectomy Surgery Patients

		Hemoglobin A_{1c} levels				
	Overall	**< 5.7%[a]**	**5.7%-6.4%**	**6.5%-8.9%**	**≥ 9.0%**	***P* value[b]**
Total, No.	59,316	48,941 (82.5)	3197 (5.4)	6044 (10.2)	1134 (1.9)	
Age, mean (SD), y	63.3 (6.9)	63.1 (6.9)	65.2 (6.6)	65.2 (6.5)	63.3 (6.5)	
Male sex, No. (%)	59,307 (99.9)	48,934 (99.9)	3197 (100)	6042 (99.9)	1134 (100)	.73
Race, No. (%)						< .001
White	37,919 (63.4)	31,966 (84.3)	1853 (4.9)	3562 (9.4)	538 (1.4)	
Black	16,749 (28.2)	13,112 (78.3)	1103 (6.6)	2024 (12.1)	510 (3.0)	
Asian	219 (0.4)	166 (75.8)	15 (6.8)	33 (15.1)	5 (2.3)	
American Indian	352 (0.6)	274 (77.8)	22 (6.3)	46 (13.1)	10 (2.8)	
Native Hawaiian	399 (0.6)	307 (76.9)	28 (7.0)	54 (13.5)	10 (2.5)	
Unknown	3678 (6.2)	3116 (84.7)	176 (4.8)	3562 (9.4)	538 (1.4)	
Ethnicity, No. (%)						< .001
Hispanic or Latino	3611 (6.1)	2719 (75.3)	256 (7.1)	526 (14.6)	110 (3.0)	
Not Hispanic or Latino	53,719 (90.6)	44,504 (82.8)	2867 (5.3)	5353 (9.9)	995 (1.8)	
Unknown	1986 (3.4)	1718 (86.5)	74 (3.7)	165 (8.3)	29 (1.5)	
Body mass index, No. (%)						< .001
< 18.5	2538 (4.3)	2331 (91.8)	71 (2.9)	107 (4.2)	29 (1.1)	
18.5-24.9	17,206 (29.0)	14,845 (86.3)	719 (4.2)	1364 (7.9)	278 (1.6)	
25.0-29.9	21,588 (36.4)	18,805 (82.5)	1176 (5.5)	2237 (10.4)	370 (1.7)	
30.0-34.9	12,448 (20.9)	9743 (78.3)	825 (6.6)	1566 (12.6)	314 (2.5)	
≥ 35.0	5536 (9.3)	4217 (67.2)	406 (7.3)	770 (13.9)	143 (2.6)	
Tobacco use, No. (%)	25,117 (42.3)	20,803 (82.8)	1436 (5.7)	2420 (9.6)	458 (1.8)	< .001
Charlson Comorbidity Index, No. (%)						< .001
1-2	1123 (1.9)	1073 (95.5)	13 (1.2)	27 (2.4)	10 (0.9)	
3-4	26,412 (44.5)	24,348 (92.2)	699 (2.7)	1148 (4.4)	217 (0.8)	
≥ 5	31,781 (53.6)	23,520 (74.0)	2485 (7.8)	4869 (15.3)	907 (2.3)	

[a]Includes patients without diabetes.
[b]Calculated using χ^2 tests with $P < .05$ considered statistically significant.

(Tables 5 and 6). These multivariable models were developed for each procedure group.

There was no significant association between HbA_{1c} level and 30-day or 90-day complications or 30-day or 90-day deaths in the cystectomy group. Although the HbA_{1c} 5.7% to 6.5% and 6.5% to 8.9% groups had significantly increased odds of 30-day and 90-day readmissions compared with the reference group, the association was not significant for the HbA_{1c} > 9.0% group.

There were significant associations between higher HbA_{1c} levels and 30-day and 90-day complications for patients who underwent prostatectomy. When compared with the reference group, the 90-day complications ORs increased progressively across each HbA_{1c} group. The group with the highest odds of 90-day complications was the HbA_{1c} ≥ 9.0% group (OR, 1.27; 95% CI, 1.14-1.43; $P < .001$). In the prostatectomy group, there was no significant trend between HbA_{1c} and readmission rates. In patients who had undergone a prostatectomy, those with HbA_{1c} ≥ 9.0% had significantly increased odds of 30-day mortality compared with the reference group (OR, 2.14; 95% CI, 1.08-4.26; $P < .03$). However, no significant association was observed between HbA_{1c} and 90-day mortality.

For patients who underwent nephrectomy, the HbA_{1c} 5.7% to 6.5% and HbA_{1c} 6.5% to 9.0% groups had significantly increased odds of 30-day complications. All 3 HbA_{1c} groups were significantly associated with 90-day complications following nephrectomy, with ORs ranging from 1.16 to 1.20 (OR, 1.20; 95% CI, 1.09-1.32 for HbA_{1c} 5.7%-6.4%; OR, 1.16; 95% CI, 1.08-1.25 for HbA_{1c} 6.5%-8.9%; and OR, 1.19; 95% CI, 1.04-1.36; $P = .04$ for HbA_{1c} ≥ 9.0%) of having complications within 90 days of surgery (OR, 1.19; 95% CI, 1.04-1.36; $P = .04$). Additionally, increasing HbA_{1c} were associated with 90-day readmissions. At the highest level, HbA_{1c} ≥ 9.0% was associated with 21% increased odds of readmission within 90 days of surgery (OR, 1.21; 95% CI, 1.05-1.38; $P = .006$). There was no association between HbA_{1c} and mortality following nephrectomy surgery.

DISCUSSION

Long-term impairment of glucose tolerance associated with DM is known to cause vascular, neurologic, and infectious complications. Several

TABLE 3. Baseline Characteristics of Nephrectomy Surgery Patients

		Hemoglobin A_{1c} levels				
	Overall	< 5.7%[a]	5.7-6.4%	6.5-8.9%	≥ 9.0%	*P* value[b]
Total, No.	30,152	21,988	2445	4912	955	
Age, mean (SD), y	64.7 (9.9)	63.9 (10.5)	67.0 (8.4)	66.5 (8.3)	63.3 (8.5)	
Male sex, No. (%)	29,431 (97.1)	21,303 (96.9)	2389 (97.7)	4806 (97.8)	933 (97.7)	< .001
Race, No. (%)						< .001
White	21,594 (71.3)	15,691 (71.4)	1724 (70.5)	3540 (72.1)	639 (66.9)	
Black	5737 (18.9)	4092 (18.6)	516 (21.1)	904 (18.4)	225 (23.6)	
Asian	97 (0.3)	70 (0.3)	6 (0.3)	20 (0.4)	1 (0.1)	
American Indian	197 (0.6)	129 (0.6)	16 (0.5)	42 (0.9)	10 (1.1)	
Native Hawaiian	196 (0.6)	126 (0.6)	23 (0.9)	39 (0.8)	8 (0.8)	
Unknown	2479 (8.2)	1880 (8.5)	160 (6.5)	367 (7.5)	72 (7.5)	
Ethnicity, No. (%)						< .001
Hispanic or Latino	1815 (5.9)	1181 (5.4)	174 (7.1)	378 (7.7)	81 (8.5)	
Not Hispanic or Latino	26,990 (89.1)	19,616 (89.2)	2187 (89.5)	4355 (88.7)	832 (87.1)	
Unknown	1495 (4.9)	1191 (5.4)	83 (3.4)	179 (3.6)	42 (4.4)	
Body mass index, No. (%)						< .001
< 18.5	1427 (4.7)	1252 (5.7)	57 (2.3)	89 (1.8)	29 (3.0)	
18.5-24.9	8736 (28.8)	6941 (31.6)	569 (23.3)	1029 (20.9)	197 (20.6)	
25.0-29.9	9456 (31.2)	6854 (31.2)	780 (31.9)	1531 (31.2)	291 (30.5)	
30.0-34.9	6263 (20.7)	4226 (19.2)	575 (23.5)	1234 (25.1)	228 (23.9)	
≥ 35.0	4418 (14.6)	2715 (12.4)	464 (18.9)	1029 (20.9)	210 (21.9)	
Tobacco use, No. (%)	15,037 (49.6)	11,000 (50.0)	1236 (50.5)	2317 (47.2)	484 (50.7)	.002
Charlson Comorbidity Index, No. (%)						< .001
1-2	1634 (5.4)	1496 (6.8)	36 (1.5)	80 (1.6)	22 (2.3)	
3-4	6842 (22.7)	87.5 (27.4)	238 (9.7)	509 (10.4)	109 (11.4)	
≥ 5	21,676 (71.8)	14,359 (65.6)	2170 (88.7)	4323 (88.0)	824 (86.3)	

[a]Includes patients without diabetes.
[b]Calculated using χ^2 tests with $P < .05$ considered statistically significant.

TABLE 4. HbA_{1c} and Diabetes Data by Procedure

	90 d HbA_{1c}, No. (%)	HbA_{1c}, mean (SD)	HbA_{1c} < 5.7%, No. (%)[a]	HbA_{1c} 5.7%-6.4%, No. (%)	HbA_{1c} 6.5%-8.9%, No. (%)	HbA_{1c} ≥ 9.0%, No. (%)
Cystectomy	3240 (40.3)	6.5 (1.36)	6346 (79.0)	526 (6.6)	994 (12.4)	165 (2.0)
Prostatectomy	22,764 (38.4)	6.4 (1.31)	48,941 (82.5)	3197 (5.4)	6044 (10.1)	1134 (1.9)
Nephrectomy	15,106 (50.1)	6.6 (1.37)	21,841 (72.4)	2444 (8.1)	4912 (16.2)	955 (3.2)

Abbreviation: HbA_{1c}, hemoglobin A_{1c}.
[a]Includes patients without diabetes.

studies have demonstrated that elevated preoperative HbA_{1c} levels are associated with increased postoperative complications across various surgical types. To our knowledge, this is the first study to examine the association between perioperative HbA_{1c} and outcomes following cystectomy, prostatectomy, and nephrectomy. Using VINCI, we analyzed 106,740 veterans undergoing urologic oncology surgery and discovered that elevated perioperative HbA_{1c} values were significantly associated with 30-day and 90-day complications following prostatectomy and nephrectomy. Additionally, we found a significant association between HbA_{1c} ≥ 9.0% and 30-day death following prostatectomy. There was no significant association between HbA_{1c} values and postoperative death following cystectomy or nephrectomy.

In our study, HbA_{1c} values were categorized into < 5.7%, 5.7% to 6.4%, 6.5% to 8.9%, and ≥ 9.0%. We found significant associations with 30-day and 90-day complications following prostatectomy with the highest odds of 90-day complications in the HbA_{1c} ≥ 9.0% group (OR, 1.27; 95% CI, 1.14-1.43; $P < .001$). We report similar findings for those undergoing nephrectomy. Those with HbA_{1c} ≥ 9.0% were found to have 19% higher odds of 90-day complications compared with those in the reference group with HbA_{1c} < 5.7% or no history of DM (OR, 1.19; 95% CI, 1.04-1.36; $P = .043$). Although HbA_{1c} 6.5%-8.9% was significantly associated with 90-day complications following cystectomy (OR, 1.28; 95% CI, 1.04-1.57), no other significant associations were found between HbA_{1c}

TABLE 5. Patient Outcomes Following Oncologic Procedures

Procedure	Overall	Hemoglobin A_{1c} level				
		< 5.7%[a]	5.7%-6.4%	6.5%-9.0%	≥ 9.0%	*P* value[b]
Cystectomy, No. (%)	8030					
Complications						
30 d	6022 (75.0)	4697 (74.0)	413 (78.5)	788 (79.3)	124 (75.6)	.001
90 d	6734 (83.9)	5257 (82.8)	460 (87.4)	874 (87.9)	143 (87.2)	< .001
Readmissions						
30 d	2579 (32.1)	1970 (31.0)	199 (37.8)	361 (36.3)	49 (29.8)	< .001
90 d	3707 (46.2)	2839 (44.7)	268 (50.9)	517 (52.0)	83 (50.6)	< .001
Death						
30 d	199 (2.5)	150 (2.4)	19 (3.6)	25 (2.5)	5 (3.1)	.34
90 d	539 (6.7)	428 (6.7)	41 (7.8)	61 (6.1)	9 (5.5)	.59
Prostatectomy, No. (%)	59,316					
Complications						
30 d	19,737 (33.3)	15,790 (32.3)	1198 (37.5)	2317 (38.3)	432 (38.1)	< .001
90 d	23,644 (39.9)	18,869 (38.6)	1470 (45.9)	2768 (45.8)	537 (47.3)	< .001
Readmissions						
30 d	17,891 (30.2)	14,515 (29.7)	1008 (31.5)	1993 (32.9)	375 (33.1)	< .001
90 d	19,203 (32.4)	15,533 (31.7)	1093 (34.2)	2152 (35.6)	425 (37.5)	< .001
Death						
30 d	208 (0.4)	153 (0.31)	14 (0.4)	32 (0.5)	9 (0.8)	.002
90 d	356 (0.6)	75.3 (0.6)	23 (0.7)	54 (0.9)	11 (0.9)	.002
Nephrectomy, No. (%)	30,152					
Complications						
30 d	17,819 (59.1)	12,504 (57.3)	1593 (65.2)	3134 (63.8)	588 (61.6)	< .001
90 d	19,677 (65.3)	13,808 (63.2)	1746 (71.4)	3464 (70.5)	659 (69.0)	< .001
Readmissions						
30 d	9425 (31.3)	6715 (30.7)	775 (31.7)	1619 (33.0)	316 (33.1)	.01
90 d	11,065 (36.7)	7841 (35.9)	911 (37.3)	1928 (39.3)	385 (40.3)	< .001
Death						
30 d	297 (1.0)	215 (1.0)	28 (1.2)	43 (0.9)	11 (1.2)	.68
90 d	654 (2.2)	464 (2.1)	48 (1.9)	116 (2.4)	26 (2.7)	.40

[a]Includes patients without diabetes.
[b]Calculated using χ^2 tests with $P < .05$ considered statistically significant.

categories and 30-day complications or death following cystectomy. It is unclear why a more consistent association does not exist across all HbA_{1c} categories for this procedure, but this may be related to other unaccounted clinical factors influencing the outcomes.

The $HbA_{1c} \geq 9.0\%$ group had a significantly increased risk of 30-day death following prostatectomy in our study (OR, 2.14; 95% CI, 1.08-4.26; $P = .03$). However, we interpret these results with caution. The 30-day mortality after prostatectomy was low in the overall cohort (0.4%, 208 deaths) and in the $HbA_{1c} \geq 9.0\%$ group (0.8%, 9 deaths) and the 95% CI was wide. It will be important to verify this finding in additional cohorts.

Limitations

This was a retrospective study, which makes it difficult to control many variables that may have influenced postoperative outcomes. Additionally, the clinical characteristics and outcomes data rely on administratively coded data, which can be prone to error. Furthermore, while this was a large, national dataset, patients received care over a long period of time and at several different institutions, which may limit the generalizability of the findings to contemporary patient care. We also recognize that HbA_{1c} values were not available in the perioperative period for all patients. We grouped those with missing HbA_{1c} values into the reference category if they did not have a diagnostic code for DM. It is possible that some patients grouped into the reference category had undiagnosed DM or elevated HbA_{1c}, which would theoretically lessen the magnitude of the findings in our multivariable analysis. Finally, despite our large cohort, 30-day and 90-day deaths were quite uncommon; larger datasets are needed to further investigate the association between perioperative HbA_{1c} and mortality.

CONCLUSIONS

The results from this study suggest that elevated perioperative HbA_{1c} is significantly associated with higher odds of 30-day and 90-day complications following prostatectomy and nephrectomy with the strongest associations noted for $HbA_{1c} \geq 9.0\%$. Prospective investigation is warranted to determine whether reducing HbA_{1c} values preoperatively would mitigate the risk of postoperative complications following urologic oncology surgeries.

TABLE 6. Multivariable Logistic Regressions by HbA_{1c} Levels

Multivariable[a]	Cystectomy, OR (95% CI)	Prostatectomy, OR (95% CI)	Nephrectomy, OR (95% CI)
30 d complication by HbA_{1c} level, %			
< 5.7 or no DM	ref	ref	ref
5.7-6.4	1.04 (0.83-1.30)	1.05 (0.97-1.13)	1.16 (1.06-1.27)[b]
6.5-8.9	1.16 (0.98-1.37)	1.11 (1.05-1.17)[b]	1.10 (1.03-1.18)[b]
≥ 9.0	0.95 (0.67-1.36)	1.17 (1.04-1.32)[b]	1.07 (0.93-1.26)
90 d complication by HbA_{1c} level, %			
< 5.7 or no DM	ref	ref	ref
5.7-6.4	1.16 (0.88-1.52)	1.12 (1.04-1.21)[b]	1.20 (1.09-1.32)[b]
6.5-8.9	1.28 (1.04-1.57)[b]	1.13 (1.07-1.19)[b]	1.16 (1.08-1.25)[b]
≥ 9.0	1.17 (0.75-1.82)	1.27 (1.14-1.43)[b]	1.19 (1.04-1.36)[b]
30 d readmission by HbA_{1c} level, %			
< 5.7 or no DM	ref	ref	ref
5.7-6.4	1.37 (1.12-1.64)[b]	0.99 (0.92-1.08)	1.06 (0.96-1.16)
6.5-8.9	1.19 (1.03-1.37)[b]	1.06 (1.01-1.13)[b]	1.10 (1.03-1.18)[b]
≥ 9.0	1.03 (0.75-1.42)	1.01 (0.89-1.14)	1.13 (0.99-1.29)
90 d readmission by HbA_{1c} level, %			
< 5.7 or no DM	ref	ref	ref
5.7-6.4	1.25 (1.04-1.49)[b]	1.01 (0.94-1.09)	1.05 (0.95-1.14)
6.5-8.9	1.29 (1.13-1.48)[b]	1.07 (1.01-1.14)[b]	1.15 (1.08-1.23)[b]
≥ 9.0	1.21 (0.99-1.65)	1.10 (0.97-1.25)	1.21 (1.05-1.38)[b]
30 d death by HbA_{1c} level, %			
< 5.7 or no DM	ref	ref	ref
5.7-6.4	1.45 (0.91-2.32)	0.92 (0.51-1.68)	0.91 (0.60-1.37)
6.5-8.9	0.73 (0.45-1.16)	1.41 (0.96-2.07)	0.69 (0.49-0.97)
≥ 9.0	1.09 (0.47-2.55)	2.14 (1.08-4.26)[b]	1.05 (0.59-1.86)
90 d death by HbA_{1c} level, %			
< 5.7 or no DM	ref	ref	ref
5.7-6.4	1.19 (0.85-1.66)	0.91 (0.59-1.44)	0.83 (0.61-1.12)
6.5-8.9	0.74 (0.59-0.99)	1.26 (0.93-1.70)	0.96 (0.77-1.19)
≥ 9.0	0.65 (0.32-1.29)	1.52 (0.84-2.75)	1.36 (0.94-1.97)

Abbreviations: DM, diabetes mellitus; HbA_{1c}, hemoglobin A_{1c}; OR, odds ratio.
[a]Model included age, sex, race, ethnicity, body mass index, smoking status, and Charlson Comorbidity Index.
[b]$P < .05$.

Author affiliations
[a]Columbia University Irving Medical Center, New York, New York
[b]James J. Peters Veterans Affairs Medical Center, Bronx, New York
[c]Touro College of Osteopathic Medicine, New York, New York

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This study was deemed exempt by the James J. Peters Veterans Affairs Medical Center Institutional Review Board.

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SUPPLEMENTARY TABLE 1. LOINC for Hemoglobin A_{1c}

	ICD 10 PCS		*ICD 10* CM		*CPT* code	
Cystectomy	0TTB0ZZ	Resection of bladder, open approach	C67	Malignant neoplasm of bladder	51550	Cystectomy, partial
	0TTB4ZZ	Resection of bladder, percutaneous endoscopic approach	C67.0	Malignant neoplasm of trigone of bladder	51570	Cystectomy, complete (separate procedure)
	0TTB7ZZ	Resection of bladder, via natural or artificial opening	C67.1	Malignant neoplasm of dome of bladder	51580	Cystectomy, complete, with ureterosigmoidostomy or ureterocutaneous diversion
	0TTB8ZZ	Resection of bladder, via natural or artificial opening endoscopic	C67.2	Malignant neoplasm of lateral wall of bladder	51555	Cystectomy, partial, complicated
			C67.3	Malignant neoplasm of anterior wall of bladder	51565	Cystectomy, partial, with ureteral reimplantation
			C67.4	Malignant neoplasm of posterior wall of bladder	51590	Cystectomy, with ileal conduit or sigmoid bladder
			C67.5	Malignant neoplasm of bladder neck	51575	Cystectomy, with bilateral pelvic lymphadenectomy
			C67.6	Malignant neoplasm of ureteric orifice	51596	Cystectomy, with continent urinary diversion, and open technique
			C67.7	Malignant neoplasm of urachus	51585	Cystectomy, with ureterosigmoidostomy or ureterocutaneous diversion, with bilateral pelvic lymphadenectomy
			C67.8	Malignant neoplasm of overlapping sites of bladder	51595	Cystectomy, with ileal conduit or sigmoid bladder, with bilateral pelvic lymphadenectomy
			C67.9	Malignant neoplasm of bladder, unspecified	51597	Pelvic exenteration

Nephrectomy	0TT00ZZ	Resection of right kidney, open approach	C64	Malignant neoplasm of kidney, except renal pelvis	50220	Removal of kidney and partial removal of ureter
	0TT04ZZ	Resection of right kidney, percutaneous endoscopic approach	C64.1	Malignant neoplasm of right kidney, except renal pelvis	50225	Removal of kidney and partial removal of ureter complicated by previous surgery on same kidney
	0TT10ZZ	Resection of left kidney, open approach	C64.2	Malignant neoplasm of left kidney, except renal pelvis	50230	Nephrectomy, including partial ureterectomy, any open approach including rib resection; radical, with regional lymphadenectomy and/or vena caval thrombectomy
	0TT14ZZ	Resection of left kidney, percutaneous endoscopic approach	C64.9	Malignant neoplasm of unspecified kidney, except renal pelvis	50234	Nephrectomy with total ureterectomy and bladder cuff; through same incision
	0TT20ZZ	Resection of bilateral kidneys, open approach			50236	Removal of kidney and ureter with partial removal of bladder through separate incision
	0TT24ZZ	Resection of bilateral kidneys, percutaneous endoscopic approach			50240	Partial removal of kidney
	0TB00ZZ	Excision of right kidney, open approach			50543	Partial nephrectomy
	0TB04ZZ	Excision of right kidney, percutaneous endoscopic approach			50545	Removal of kidney and lymph nodes using an endoscope (radical nephrectomy)
	0TB10ZZ	Excision of left kidney, open approach			50546	Removal of kidney and partial removal of ureter using an endoscope
	0TB14ZZ	Excision of left kidney, percutaneous endoscopic approach			50548	Removal of kidney and ureter using an endoscope
Prostatectomy	0VT00ZZ	Resection of Prostate, Open Approach	C61	Malignant neoplasm of prostate	55842	Prostatectomy, retropubic radical, with or without nerve sparing; with lymph node biopsy(s) (limited pelvic lymphadenectomy)
	0VT04ZZ	Resection of prostate, percutaneous endoscopic approach	D07.5	Carcinoma in situ of prostate	55845	Prostatectomy, retropubic radical, with or without nerve sparing; with bilateral pelvic lymphadenectomy, including external iliac, hypogastric, and obturator nodes
	0VT07ZZ	Resection of prostate, via natural or artificial opening			55866	Laparoscopy, surgical prostatectomy, retropubic radical, including nerve sparing, includes robotic assistance, when performed
	0VT08ZZ	Resection of prostate, via natural or artificial opening endoscopic				

Abbreviations: *CPT*, *Current Procedural Terminology*; *ICD-10, International Classification of Diseases, Tenth Revision;* LOINC, Logical Observation Identifiers, Names, and Codes.

SUPPLEMENTARY TABLE 2. Complication Diagnostic Codes

Complication	Example	*ICD ninth revision* code	*ICD 10th revision* code
Hemorrhage bleeding	Hemorrhage complicating procedure, acute hemorrhagic anemia, hematoma, blood transfusion, iron deficiency anemia secondary to blood loss	V58.2, 998.1, 998.11, 998.12, 285.1, 39.98, 54.12, 39.41, 39.49, 34.43, 99.00, 99.02, 99.03, 99.04, 459.0, 568.81, 998.11, 280, 285.9	D50.0, D62, R58
Cardiac	Myocardial infarction, hypertensive disease with heart failure, heart failure, supraventricular tachycardia, atrial fibrillation, cardiac arrest, cardiogenic shock	410.1, 410.2, 410.3, 410.4, 410.5, 410.6, 410.7, 410.8, 410.9, 402.01, 402.11, 402.91, 428.xx, 426.0, 427.0, 427.1, 427.2, 427.31, 427.32, 427.41, 427.42, 427.9, 427.5, 997.1, 785.51	I21.09, I21.19, I21.11, I21.29, I21.4, I21.3, I11.0, I50.9, I44.2, I47.0, I47.1, I47.2, I47.9, I48.0, I48.1, I48.2, I48.3, I48.4, I48.91, I48.92, I49.01, I49.02, I49.9, I46.9, I97.88, I97.89
Respiratory	Atelectasis, pneumonia (any type) and ventilator-associated pneumonia, pneumothorax, transfusion-related acute lung injury, chronic respiratory failure with hypoxia, acute respiratory failure with hypoxia	518, 514, 518.4, 518.5, 518.82, 466. xx, 480.xx, 481, 482.xx, 483.xx, 485, 486, 507.0, 799.1, 512.1, 518.7, 997.3, 518.81, 518.84, 997.3x, 483.x, 484.x, 507.x, 997.31, 997.39	J90, J91.8, J81.0, J80, J95.821, J95.822, J96.00, J96.01, J96.02, J96.90, J96.91, J96.92, J96.10, J96.11, J96.20, J96.21, J96.22, J13, J14, J15.0, J15.1, J15.20, J15.211, J15.212, J15.29, J15.3, J15.4, J15.5, J15.6, J15.8, J15.9, J18.0, J18.1, J18.2, J18.8, J18.9, J95.851, J95.859, J69.0, J69.8, R09.2, J95.811, J95.84
Gastrointestinal	Paralytic ileus, nausea, vomiting, diarrhea, constipation, small bowel obstruction, gastrointestinal bleeding, gastric or duodenal ulcer, bowel leak	530.82, 531.0x, 531.1x, 531.2x, 531.4x, 531.6x, 532.0x, 532.1x, 532.2x, 532.4x, 532.6x, 533.0x, 533.1x, 533.2x, 533.4x, 533.6x, 534.0x, 534.1x, 534.2x, 534.4x, 534.6x, 535.x1, 578.9, 997.4, 560, 560.0, 560.2, 560.2, 560.3x, 560.8, 560.81, 560.89, 560.9	K56.x, K20.x, K21.x, K22.x, K22.11, K22.8, K25.x, K26.x, K28.x, K29.6, K28.7, K92.x, K91.3, K91.89, K91.x, K90.8, K90.9
Genitourinary	Renal or perinephric abscess, urine leak, urinary obstruction, urinary fistula, hematuria, other postprocedural complications and disorders of genitourinary systems, stoma complications: parastomal hernia, stomal ischemia	593.82, 596.1, 596.2, 596.3, 997.5, 593.8x, 442.1, 997.72, 445.81, 902.4x, V44.6, V55.6, 866.xx, 867.x, 868.14, 868.04, 599.1, 619.0, 788.8, 567.89, 55.12, 55.21, 55.22, 55.29, 55.8x, 55.92, 55.93, 55.94, 87.73, 87.74, 88.75, 88.45, 97.61, 97.62, 56.0, 56.31, 56.39, 56.8x, 56.6x, 56.74, 56.75, 56.79, 57.0, 57.93, 57.32, 59.0x, 59.2x, 59.92, 59.93, 590.3, 46.4, 56.52, 599.6x, 593.3, 593.4, 593.5, 591, 5848, 9975, 55.0, 55.02, 55.03, 59.8, 56.72	N28.89, N30, N32.1, N32.2, N32.3, N99.89, N13.4, N13.30, N13.8,
Wound and hernia	Wound seroma, wound infection, poor wound healing, secondary intention healing, wound dehiscence, fascial dehiscence and/or evisceration, abdominal wall hernia, incisional hernia	879.2, 998.31, 998.32, 998.83, 998.3, 998.5, 998.59, 998.51, 998.6, 958.3, 998.3x, 998.5x, 54.61, 54.62, 54.63, 54.72, 86.04, 86.05, 86.22, 86.28, 551.9, 552.8, 552.9, 553.9, 553.21, 53.5, 53.51, 53.59, 53.6, 53.61, 53.62, 53.63, 53.69	K43.3, K43.4, K43.5, K45.0, K46.1, K46.0, K46.9
Thrombosis/embolic	Phlebitis, thrombosis of vein or artery, deep vein thrombosis, pulmonary embolism	415.1, 451.1x, 451.2, 451.81, 451.9, 453.8, 453.9, 997.2, 999.2, 444.22, 444.81, 451.11, 451.19, 453.40, 453.41, 415.11, 415.13, 415.19	I26.02, I26.09, I26.9, I26.99, I80.10, I80.12, I80.13, I80.201, I80.202, I80.291, I80.292, I80.293, I80.299, I8.2401, I82.402, I82.403, I82.409, I82.411, I82.412, I80.203, I80.209, I80.211, I80.212, I80.213, I80.219, I80.221, I80.222, I80.223, I80.229, I80.231, I80.232, I80.233, I80.239, I82.413, I82.419, I82.421, I82.422, I82.423, I82.429, I82.431, I82.432, I82.433, I82.439, I82.4Y1, I82.4Y2, I82.4Y3, I82.4Y9, I74.3, I74.5, I80.11

Infection and sepsis	Pyelonephritis, unspecified kidney infection, urinary tract infection, peritoneal abscess, necrotizing fasciitis, *Clostridium difficile*, drainage of abscess, MRSA sepsis, septic shock, postoperative sepsis, bacteremia	590.2, 580.8, 590.80, 590.1, 590.81, 590.00, 590.11, 038.0, 038.2, 038.3, 038.4, 038.8, 038.9, 996.64, 599.0, 590.9, 567.22, 686.8, 686.9, 728.86, 009.1, 008.45, 567, 567.1, 567.2x, 567.3x, 567.81, 567.82, 567.9, 320.xx, 510.x, 513.x, 519.2, 683, 038.xx, 785.52, 785.50, 785.59, 998.0, 995.91, 995.92, 996.62, 999.3, 999.31, 790.7	N12, N16, N11.0, N10, A40.9, R78.81, T83.510, N39.0, K65.1, A02.1, A40.0, A40.1, A40.3, A41.01, A41.02, A41.1, A41.2, A41.3, A41.4, A415.0, A41.51, A41.52, A41.53, A41.59, A41.81, A41.89, A41.9, A42.7, A54.86, B37, R65.20, R65.21, L08.89, L08.9, M72.6, A09, A04.7, A04.71, A04.72, A40.x, A41.x, R65.xx, T80.2, T80.21, T80.219, R78.81, T81.12
Renal failure, metabolic disturbances, dehydration, failure to thrive, malnutrition	Renal failure, acute kidney injury, acute kidney failure, dialysis catheter placement, acidosis, volume depletion, dehydration, electrolyte disorders	586, 584, v45.1x, v56.0, v56.1, 38.95, 39.27, 39.95, 54.98, 55.6, 276.2, 276.5, 276.51, 276.9, E87.3, 263.9, 263.1, 263, 263.2, 263.8, 783.7	E87.2, E86.0, E87.8, R62.7
Neurologic	Subarachnoid, subdural, or intracranial hemorrhage; occlusion or stenosis of cerebral artery—no thrombosis, ischemic or hemorrhagic stroke, neuropathy	436, 434.91, 434.11, 434.01, 997.01, 997.02, 997.0x, 433.xx, 434.xx, 430, 431, 432.1, 432.9, 997.09, 356.8	I67.89, I63.5, I63.40, I63.30, G97.81, G97.82, I97.811, I97.821, I65, I63, I66, I60, I61, I62, G97.81, G60.3, G62
Miscellaneous and surgical	Lymphocele, lower extremity swelling, uncontrolled pain, lymphedema, accidental cut/puncture/perforation, fall, intraoperative repair of colon or small bowel (bowel injury), unspecified complication	39.79, E870.0, 998.8, 998.89, 998.9, 999.9, E878.8, E878.9, 997.9, 999.4, 999.5, 999.6, 999.7, 999.8x, e876.x, e878.x, e911, e912, e879.x, 997.99	Y83.8, Y83.9, Y84.0, I89.8, W01, W02, W03, W04, W05, W06, W07, W08, W09, W10, W11, W12, W13, W14, W15, W16, W17, W18, W19

Abbreviations: *ICD*, *International Classification of Diseases*; MRSA, methicillin-resistant *Staphylococcus aureus*.