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Association Between Perioperative Diuretic Use and Postoperative Outcomes Following Dermatologic Surgery: A TriNetX Based Cohort Study

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Abstract

Patients undergoing Mohs micrographic surgery (MMS) on perioperative diuretics represent a medically complex population, yet the impact of diuretic use on postoperative outcomes remains underexplored. Despite use in patients with cardiometabolic comorbidities, limited research has evaluated how perioperative diuretic exposure influences postoperative outcomes following MMS. This study investigates the association between perioperative diuretic use and postoperative outcomes following MMS. Utilizing the TriNetX database, MMS patients were matched on a 1:1 basis according to perioperative diuretic use. Outcome variables were evaluated over a 30 and 90-day follow-up period. Among 37,781 matched patients, diuretic use was associated with higher odds of surgical site infection at both 30 days (OR 1.29, 95% CI 1.03–1.62, $p = 0.03$) and 90 days (OR 1.36, 95% CI 1.12–1.65, $p < 0.001$), as well as substantially increased odds of rash or cellulitis at 30 days (OR 1.95, 95% CI 1.68–2.26, $p < 0.001$) and 90 days (OR 1.92, 95% CI 1.74–2.13, $p < 0.001$). Perioperative diuretic use was linked to increased odds of infection, rash or cellulitis, postoperative pain, opioid use, emergency department visits, sepsis, and short-term mortality, with time-to-event analysis identifying loop and osmotic diuretics as the primary drivers of risk.

Introduction

Mohs micrographic surgery (MMS) is a widely utilized technique for the management of nonmelanoma skin cancers.[1] MMS offers superior margin control and high cure rates while maximizing tissue preservation.[1] One area of growing interest is the impact of diuretics on postoperative outcomes in dermatologic surgery. Certain classes of diuretics have been associated with dehydration, electrolyte disturbances, and photosensitivity which are factors that may affect wound healing, hemostasis, and postoperative recovery in cutaneous surgery.[2,3]

While the effects of diuretics on surgical outcomes have been examined in other surgical disciplines, including orthopedic and general surgery, data evaluating their impact in dermatology remain limited.[4] To date, no large-scale studies have investigated the association between perioperative diuretic use and postoperative outcomes following MMS. The aim of this study is to evaluate the effect of perioperative diuretic use on 30- and 90-day medical complications and surgical outcomes following MMS using TriNetX. By clarifying the risks or potential associations linked to these commonly prescribed medications, this study seeks to inform perioperative decision-making and optimize outcomes for patients undergoing MMS.

Methods

We conducted a retrospective cohort study using the TriNetX U.S. Collaborative Network, a federated electronic health record platform comprising approximately 132 million patients across 69 healthcare organizations at the time of analysis. Adults aged ≥ 18 years who underwent Mohs micrographic surgery

between January 4, 2004 and January 18, 2026 were identified using the standardized Mohs procedure code (1003602), with the date of surgery defined as the index event.

Patients were categorized into exposed and control cohorts based on perioperative diuretic use, defined as a documented prescription from 12 months before to 1 month after the index Mohs surgery. Patients were additionally required to have evidence of diuretic use within 1 year of surgery and a minimum cumulative duration of therapy of at least 6 months. Diuretics were identified using Anatomical Therapeutic Chemical codes and evaluated both as a composite exposure and by individual classes, including thiazide and related diuretics (CV701), loop diuretics (CV702), potassium-sparing diuretics (CV704), carbonic anhydrase inhibitors (CV703), and osmotic diuretics (B05BC), with each class analyzed separately against its matched control cohort.

Propensity score matching was performed in a 1:1 ratio using logistic regression with nearest-neighbor matching and a caliper of 0.01. Matching variables included age, sex, race and ethnicity, body mass index, and comorbidities including diabetes mellitus, hypertension, chronic kidney disease (all stages), heart failure, liver disease, and tobacco use. After matching, baseline demographic and clinical characteristics were well balanced between cohorts, with no statistically significant residual differences in included covariates. See Table 1 for demographic information.

Table 1
Baseline Characteristics of Patients Undergoing Mohs Surgery With and Without Perioperative Diuretic Use Before and After Propensity Score Matching

Characteristic	Before Matching			After Matching		
	Diuretics and Mohs (n = 53,801)	Mohs No Diuretics (n = 274,704)	P-Value	Diuretics and Mohs (n = 37,781)	Mohs No Diuretics (n = 37,781)	P-Value
Demographics						
Age at Index (Mean ± SD)	73.8 ± 10.3	66.3 ± 13.0	< 0.0001	72.4 ± 10.4	72.4 ± 10.4	0.81
Sex						
Male	31,642 (58.81%)	152,608 (55.55%)	< 0.0001	21,694 (57.42%)	21,580 (57.12%)	0.40
Female	22,157 (41.18%)	122,078 (44.44%)	< 0.0001	16,087 (42.58%)	16,197 (42.87%)	0.42
Race						
White	51,529 (95.78%)	250,614 (91.23%)	< 0.0001	36,050 (95.42%)	36,129 (95.63%)	0.16
Asian	117 (0.22%)	599 (0.22%)	0.98	89 (0.24%)	76 (0.20%)	0.31
Hispanic	224 (0.61%)	788 (0.31%)	< 0.0001	90 (0.24%)	77 (0.21%)	0.32
Black or African American	275 (0.51%)	768 (0.28%)	< 0.0001	159 (0.42%)	145 (0.38%)	0.42
Diagnoses						
Type 2 Diabetes	18,739 (34.83%)	17,209 (6.27%)	< 0.0001	9,966 (26.38%)	9,693 (25.66%)	0.02
Type 1 Diabetes	3,244 (6.03%)	1,654 (0.60%)	< 0.0001	1,220 (3.23%)	1,116 (2.95%)	0.03
Essential Hypertension	47,980 (89.18%)	55,910 (20.35%)	< 0.0001	32,006 (84.72%)	32,702 (86.56%)	0.06
Chronic Kidney Disease	15,855 (29.47%)	8,259 (3.01%)	< 0.0001	6,534 (17.29%)	6,137 (16.24%)	0.07
Heart Failure	16,148 (30.01%)	3,172 (1.16%)	< 0.0001	3,437 (9.10%)	2,787 (7.38%)	0.09
Tobacco Use	2,242 (4.17%)	3,882 (1.41%)	< 0.0001	1,360 (3.60%)	1,315 (3.48%)	0.38
Diseases of Liver	7,673 (14.26%)	8,253 (3.00%)	< 0.0001	4,054 (10.73%)	4,018 (10.64%)	0.67

Characteristic	Before Matching			After Matching		
	Diuretics and Mohs (n = 53,801)	Mohs No Diuretics (n = 274,704)	P-Value	Diuretics and Mohs (n = 37,781)	Mohs No Diuretics (n = 37,781)	P-Value
Demographics						
Alcohol Related Disorders	2,904 (5.40%)	4,482 (1.63%)	< 0.0001	1,703 (4.51%)	1,719 (4.55%)	0.78
Cannabis Related Disorders	451 (0.84%)	915 (0.33%)	< 0.0001	272 (0.72%)	273 (0.72%)	0.97
Labs (BMI)						
Mean BMI ± SD	29.8 ± 6.4	27.3 ± 5.3	< 0.0001	29.4 ± 6.25	28.9 ± 5.71	0.08
25–30 kg/m2	25,694 (47.76%)	69,562 (25.32%)	< 0.0001	16,906 (44.75%)	17,117 (45.31%)	0.12
18–25 kg/m2	15,297 (28.43%)	57,096 (20.79%)	< 0.0001	10,375 (27.46%)	10,556 (27.94%)	0.14
At least 35 kg/m2	13,693 (25.45%)	16,084 (5.86%)	< 0.0001	7,152 (18.93%)	7,044 (18.64%)	0.31
At most 18 kg/m2	2,766 (5.14%)	4,022 (1.46%)	< 0.0001	1,343 (3.56%)	1,309 (3.47%)	0.50
30–35 kg/m2	21,155 (39.32%)	36,238 (13.19%)	< 0.0001	12,512 (33.12%)	12,518 (33.13%)	0.96

Table 2
30 and 90-Day Postoperative Outcomes in Patients Undergoing Mohs Surgery Taking Diuretics vs Controls

Outcome Name	Timepoint	Diuretics and Mohs (n = 37,781)	Controls (n = 37,781)	Odds Ratio (95% CI)	P-Value
Rash/Cellulitis	30 Days	501 (1.33%)	259 (0.69%)	1.95 (1.68, 2.26)	< 0.0001
	90 Days	1,088 (2.88%)	574 (1.52%)	1.92 (1.74, 2.13)	< 0.0001
Opioid Prescription	30 Days	4,443 (11.76%)	2,538 (6.72%)	1.85 (1.76, 1.95)	< 0.0001
	90 Days	7,131 (18.88%)	3,992 (10.57%)	1.97 (1.89, 2.05)	< 0.0001
Post Op Check	30 Days	10,315 (27.30%)	12,975 (34.34%)	0.72 (0.70, 0.74)	< 0.0001
	90 Days	11,615 (30.74%)	14,048 (37.18%)	0.75 (0.73, 0.77)	< 0.0001
Acute Pain	30 Days	153 (0.41%)	85 (0.23%)	1.80 (1.38, 2.35)	< 0.0001
	90 Days	327 (0.87%)	184 (0.49%)	1.78 (1.49, 2.14)	< 0.0001
ED Admission	30 Days	1,051 (2.78%)	567 (1.50%)	1.88 (1.69, 2.08)	< 0.0001
	90 Days	2,318 (6.14%)	1,382 (3.66%)	1.72 (1.61, 1.84)	< 0.0001
Death	30 Days	135 (0.36%)	38 (0.10%)	3.56 (2.48, 5.11)	< 0.0001
	90 Days	339 (0.90%)	129 (0.34%)	2.64 (2.16, 3.24)	< 0.0001
Hematoma/Seroma	30 Days	28 (0.07%)	23 (0.06%)	1.22 (0.70, 2.11)	0.48
	90 Days	38 (0.10%)	30 (0.08%)	1.27 (0.79, 2.04)	0.33
Wound Disruption	30 Days	102 (0.27%)	103 (0.27%)	0.99 (0.75, 1.30)	0.94
	90 Days	216 (0.57%)	188 (0.50%)	1.15 (0.95, 1.40)	0.16
Surgical Site Infection	30 Days	173 (0.46%)	134 (0.36%)	1.29 (1.03, 1.62)	0.03

Outcome Name	Timepoint	Diuretics and Mohs (n = 37,781)	Controls (n = 37,781)	Odds Ratio (95% CI)	P-Value
	90 Days	247 (0.65%)	182 (0.48%)	1.36 (1.12, 1.65)	0.002

Table 3
Cox Proportional Hazards Analysis of Skin-Related Complications Within 90 Days Following Mohs Surgery by Diuretic Exposure and Indication

Covariate	Hazard Ratio	95% CI	P value
Cohort 1 vs Cohort 2 membership	1.464	1.301–1.648	< 0.0001
Male sex	0.888	0.845–0.932	< 0.0001
Loop diuretics	1.452	1.311–1.609	< 0.0001
Osmotic diuretics	1.339	1.165–1.540	< 0.0001
Heart failure	1.309	1.202–1.425	< 0.0001
Chronic kidney disease	1.363	1.268–1.464	< 0.0001
Essential hypertension	1.568	1.471–1.671	< 0.0001
Liver disease	1.384	1.278–1.498	< 0.0001
Age at index	1.000	0.998–1.003	0.6511
Thiazides / related diuretics	0.952	0.870–1.042	0.2896
Potassium-sparing / combination diuretics	0.955	0.874–1.043	0.3052
Carbonic anhydrase inhibitor diuretics	0.914	0.719–1.162	0.4629

Postoperative outcomes were assessed at 30 and 90 days following the index surgery and analyzed by surgical site infection, wound disruption, postoperative wound check visits, acute pain, hematoma or seroma formation, rash or cellulitis, opioid prescription, sepsis, emergency department admission, and all-cause mortality. Outcomes were identified using diagnosis, procedure, and prescription records within TriNetX, and analyses were limited to outcomes available in the matched results exports. Effect estimates were reported as odds ratios with 95% confidence intervals and corresponding p values.

In a secondary analysis, we utilized Cox proportional hazards models to assess the development of skin-related complications within 90 days after Mohs surgery. The models were stratified by both diuretic class and the underlying indication for diuresis. Skin-related outcomes were identified using diagnosis codes and encompassed cellulitis and acute lymphangitis, rash or nonspecific skin eruption, procedure-related infection, wound disruption, and postoperative hematoma or seroma. For each diuretic class and indication-specific model, we reported hazard ratios along with their 95% confidence intervals.

Results

Before propensity score matching, the diuretic cohort included 53,801 patients compared with 274,704 patients in the non-diuretic control cohort and demonstrated substantial baseline differences across nearly all measured variables. Patients receiving diuretics were significantly older, more frequently male, and had markedly higher burdens of cardiometabolic and systemic comorbidities, including essential hypertension, diabetes mellitus, chronic kidney disease, heart failure, liver disease, alcohol-related disorders, and tobacco use, as well as higher mean body mass index and greater representation in overweight and obese BMI categories (all $p < 0.0001$). See Table 1 for further details.

After 1:1 propensity score matching, 37,781 patients in the diuretic cohort were successfully matched to 37,781 control patients, resulting in well-balanced cohorts across demographic characteristics, comorbid conditions, and BMI distributions. Mean age, sex, race, comorbidity prevalence, and BMI categories were closely aligned between groups, with most covariates demonstrating no statistically significant differences following matching. Small residual differences observed for type 1 and type 2 diabetes were minimal in absolute magnitude and unlikely to meaningfully impact postoperative outcome comparisons, supporting the adequacy of the matching process. 37,781 patients receiving perioperative diuretics were successfully matched to 37,781 controls undergoing Mohs surgery without diuretic exposure. Baseline demographic characteristics and comorbidities were well balanced between cohorts, with no statistically significant differences following matching.

At 30 and 90 days, diuretic use was associated with higher odds of surgical site infection at both 30 days (OR 1.29, 95% CI 1.03–1.62, $p = 0.03$) and 90 days (OR 1.36, 95% CI 1.12–1.65, $p < 0.001$), as well as substantially increased odds of rash or cellulitis at 30 days (OR 1.95, 95% CI 1.68–2.26, $p < 0.001$) and 90 days (OR 1.92, 95% CI 1.74–2.13, $p < 0.001$). Rates of hematoma or seroma formation and wound disruption were similar between cohorts with no statistically significant differences observed at either timepoint.

Patients receiving diuretics demonstrated significantly higher postoperative opioid prescriptions at 30 days (OR 1.85, 95% CI 1.76–1.95, $p < 0.001$) and 90 days (OR 1.97, 95% CI 1.89–2.05, $p < 0.001$), alongside increased odds of acute pain at both 30 days (OR 1.80, 95% CI 1.38–2.35, $p < 0.001$) and 90 days (OR 1.78, 95% CI 1.49–2.14, $p < 0.001$). Conversely, diuretic users were less likely to have postoperative wound check visits at 30 days (OR 0.72, 95% CI 0.70–0.74, $p < 0.001$) and 90 days (OR 0.75, 95% CI 0.73–0.77, $p < 0.001$).

More severe postoperative events were also more frequent among diuretic users, including higher odds of sepsis at 30 days (OR 4.34, 95% CI 3.03–6.21, $p < 0.001$) and 90 days (OR 3.59, 95% CI 2.83–4.55, $p < 0.001$), emergency department admission at 30 days (OR 1.88, 95% CI 1.69–2.08, $p < 0.001$) and 90 days (OR 1.72, 95% CI 1.61–1.84, $p < 0.001$), and all-cause mortality at 30 days (OR 3.56, 95% CI 2.48–5.11, $p < 0.001$) and 90 days (OR 2.64, 95% CI 2.16–3.24, $p < 0.001$).

Discussion

This study is a propensity-matched cohort study utilizing a national database to assess the role of diuretic use in patients undergoing MMS during the perioperative period. Our study found that diuretic use was associated with higher odds of surgical site infection, rash or cellulitis, postoperative opioid use and acute pain, as well as increased risks of sepsis, emergency department admission, and all-cause mortality at both 30 and 90 days, alongside fewer postoperative wound check visits. We also found that diuretics were not significantly associated with differences in hematoma/seroma formation or wound disruption at 30 or 90 days.

Current literature examining the perioperative impact of diuretics for MMS patients is limited, however studies examining the impact in other specialties have been conducted. It has been shown that perioperative diuretic use was independently associated with a higher risk of postoperative acute kidney injury after noncardiac surgery with the effect particularly pronounced in patients with lower propensity for diuretic use.[5] Another similar study found that postoperative diuretic use was associated with increased odds of AKI after major cardiac, thoracic, general, and vascular surgery with heightened risk within the first one to five days after exposure.[6] These findings were also confirmed in orthopedic surgery which demonstrated a twofold risk of AKI with perioperative diuretic use.[7]

Sepsis risk has also been found to be associated with diuretic use. Sun et al. found that genetically predicted diuretic use was causally associated with a 17% higher risk of sepsis (OR 1.17, 95% CI 1.03–1.34) after removing confounders after adjustment.[8] Another study found that treatment with diuretics was an independent predictor of 90-day readmission to the emergency department.[9] In renal transplant recipients, loop diuretic therapy significantly correlated with increased urinary tract infections over five years.[10]

Increased emergency department admission has also been shown to be associated with diuretic use due to electrolyte disturbances.[11] Diuretics are consistently among the top five drug classes causing adverse drug reactions leading to hospitalization.[12] A study of 1604 thiazide diuretic users presenting to an emergency department found that patients taking thiazide diuretics had significantly more episodes of syncope and falls. Therefore, thiazide diuretic use should be more closely monitored especially patients who are elderly, female, and prone to falls.[13]

Diuretic use is associated with increased all-cause mortality across diverse patient populations; however, this relationship is multifactorial and confounded by disease severity and indication for therapy. In patients with suspected coronary artery disease but without systolic heart failure or renal impairment, loop diuretic use was associated with an 82% increased risk of all-cause mortality.[14] However, evidence for this association is weak particularly in postoperative settings.

The relationship between perioperative diuretic use and postoperative complications remains poorly defined in patients undergoing MMS. It is important to note that information on surgeon experience,

reconstructive approach, and postoperative management was not available. However, our findings indicate the need for further high-quality randomized controlled studies to better characterize these associations.

Limitations:

This study has several strengths, including a large, propensity score-matched cohort derived from multiple institutions which enhances the generalizability of our findings. However, it can also be a limitation due to its retrospective observational design, potential coding inaccuracies and missing clinical detail, and residual confounding from unmeasured variables that cannot be fully addressed by matching. The retrospective design and limited granularity of the database restrict our ability to evaluate medication-related factors such as dose, duration, adherence, prescribing indication, and patient-reported outcomes.[15] Additionally, postoperative care or complications occurring outside the TriNetX network may not have been captured. Although propensity score matching was used to reduce confounders, residual bias may remain especially given the higher comorbidity burden among patients receiving diuretics. Information on surgeon experience, reconstructive approach, and postoperative management was not available. It is important to note that the associations observed in this propensity-matched analysis do not imply causation. Future prospective studies are needed to better define the relationship between perioperative diuretic use and postoperative outcomes in dermatologic surgery.

Conclusion

In this large propensity-matched analysis, perioperative diuretic use was associated with significantly higher rates of postoperative medical and skin-related complications following MMS, despite similar risks of hematoma, seroma, and wound disruption. Diuretic exposure was linked to increased odds of infection, rash or cellulitis, postoperative pain, opioid use, emergency department visits, sepsis, and short-term mortality, with time-to-event analysis identifying loop and osmotic diuretics as the primary drivers of risk. These findings highlight perioperative diuretic use as an important risk marker in patients undergoing MMS and support increased perioperative awareness and postoperative monitoring in this patient population.

Declarations

Conflicts of Interest:

None declared

Patient Consent

Not applicable

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All authors helped with the preparation and review of manuscript.

Data Availability

Data available within the article or its supplementary materials.

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