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**Original Article**

# Renal and Cardiovascular Effects of SGLT2 Inhibitors in Patients with Hypertension and Type 2 Diabetes.

**Dr. Nilesh H. Tayade[1], Vishal Shivaji Pol[2]**

[1]Assistant Professor, Department of Pharmacology, Institute of Medical Sciences and Research, Mayani, Satara, Maharashtra, India.

[2]Assistant professor cum statistician, Department of Community Medicine, Institute of medical sciences and research centre Mayani Satara, Maharashtra, India.

**Corresponding author: Vishal Shivaji Pol**

**Background:** Hypertension and type 2 diabetes mellitus (T2DM) commonly coexist and increase the risk of kidney and cardiovascular complications. Sodium-glucose cotransporter 2 (SGLT2) inhibitors may provide benefits beyond glucose lowering. This study aimed to assess renal and cardiovascular parameters among patients with hypertension and T2DM and compare findings by SGLT2 inhibitor use. **Methods:** A hospital-based cross-sectional study was described for 80 adults attending a Medicine Outpatient Department with documented hypertension and T2DM. Demographic and clinical information, medication use, blood pressure, serum creatinine, estimated glomerular filtration rate (eGFR), urinary albumin-to-creatinine ratio (UACR), and cardiovascular history were collected. Continuous and categorical variables were summarized descriptively, and group comparisons were planned using appropriate statistical tests. **Results:** Mean age was 58.6 years; 40 of 80 participants (50%) received an SGLT2 inhibitor. Mean systolic and diastolic blood pressure were 138.2 and 82.4 mmHg, respectively. Mean serum creatinine was 1.12 mg/dL and mean eGFR was 68.4 mL/min/1.73 m². UACR was available for 60 participants, of whom 36 (60%) had values ≥30 mg/g. SGLT2 inhibitor users had lower mean blood pressure, slightly higher mean eGFR, and lower mean serum creatinine and UACR than non-users. Statistical significance was not established. **Conclusion:** Patients with hypertension and type 2 diabetes mellitus who were receiving SGLT2 inhibitors had numerically lower blood pressure and slightly more favorable renal measurements than non-users. These descriptive differences are consistent in direction with benefits reported in clinical trials.

***Keywords: SGLT2 inhibitors; type 2 diabetes mellitus; hypertension; renal function; cardiovascular outcomes; estimated glomerular filtration rate; albuminuria***

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## Introduction

Hypertension and type 2 diabetes mellitus (T2DM) frequently coexist and substantially increase the risk of cardiovascular disease (CVD), heart failure, and chronic kidney disease (CKD). These conditions are linked by shared mechanisms, including endothelial dysfunction, chronic inflammation, altered renal sodium handling, and activation of neurohormonal pathways. Kidney injury and cardiovascular disease may then reinforce one another, contributing to albuminuria, declining glomerular filtration, and increased cardiovascular risk. Consequently, treatment goals extend beyond glycaemic control to reducing blood pressure and preventing renal and cardiovascular complications.[1]

Sodium–glucose cotransporter 2 (SGLT2) inhibitors—including empagliflozin, dapagliflozin, and canagliflozin—were introduced as glucose-lowering agents. They inhibit glucose and sodium reabsorption in the proximal renal tubule, increasing urinary glucose excretion. Their effects also include modest reductions in blood pressure and body weight. By increasing sodium delivery to the macula densa, SGLT2 inhibition may restore tubuloglomerular feedback and reduce intraglomerular pressure; osmotic diuresis and natriuresis may also contribute to changes in blood pressure and volume status. These mechanisms provide a pharmacological basis for benefits that extend beyond glucose lowering. [2]

Evidence from cardiovascular outcome trials established the clinical importance of this broader profile. In EMPA-REG OUTCOME, empagliflozin reduced the risk of major cardiovascular events and cardiovascular death in patients with T2DM and established CVD. [3] In DECLARE–TIMI 58, dapagliflozin reduced the combined risk of cardiovascular death or hospitalization for heart failure, although it did not significantly reduce major adverse cardiovascular events. [4] Dedicated kidney outcome trials further strengthened the evidence: CREDENCE found that canagliflozin reduced the risk of kidney failure and cardiovascular events in patients with T2DM and diabetic nephropathy, while DAPA-CKD demonstrated a reduction in worsening kidney function or death among patients with CKD, with or without T2DM.[5,6] Current diabetes guidance consequently recommends SGLT2 inhibitors with demonstrated benefit for appropriate patients with T2DM and established or high risk of cardiovascular or kidney disease. [1]

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Despite these advances, hypertension remains a central treatment consideration in this population. Blood pressure control is essential for reducing cardiovascular risk and slowing kidney damage, and many patients require multiple therapies. The renal and cardiovascular effects of SGLT2 inhibitors may therefore be particularly relevant in patients with both hypertension and T2DM, including when these drugs are used alongside established antihypertensive and kidney-protective treatments. This manuscript reviews the pharmacology of SGLT2 inhibitors and examines their renal and cardiovascular effects in patients with hypertension and T2DM, with emphasis on mechanisms of action and evidence from clinical outcome trials.

## Objectives

### Primary objective

To assess renal and cardiovascular parameters among patients with hypertension and type 2 diabetes mellitus attending the Medicine Outpatient Department, and to compare these parameters between patients receiving SGLT2 inhibitors and those not receiving them.

### Secondary objectives

- To describe SGLT2 inhibitor use, including the specific agent and duration of treatment, among the study participants.
- To assess renal status using available serum creatinine, estimated glomerular filtration rate (eGFR), and urinary albumin or albumin-to-creatinine ratio (UACR) measurements.
- To assess cardiovascular status using recorded blood pressure and documented history of cardiovascular disease.
- To examine the association between SGLT2 inhibitor use and renal and cardiovascular parameters, accounting for relevant clinical characteristics where data permit.

## Methodology

### Study design and setting

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A hospital-based observational cross-sectional study was conducted in the Medicine Outpatient Department (OPD) of **Institute of Medical Sciences and Research, Mayani, Satara, Maharashtra** to assess the renal and cardiovascular profile of patients with hypertension and type 2 diabetes mellitus (T2DM), including those receiving sodium–glucose cotransporter 2 (SGLT2) inhibitors.

**Study population and sample size**

The study included 80 adult patients attending the Medicine OPD who had documented diagnoses of hypertension and T2DM. Participants were recruited during **January to July 2014** using **consecutive sampling**, according to the eligibility criteria, after obtaining informed consent.

**Eligibility criteria**

Adults aged 18 years or older with documented hypertension and T2DM who attended the Medicine OPD and provided written informed consent were included. Patients who declined consent, could not provide the required clinical information, or had an acute illness or another condition that made participation or interpretation of study measurements inappropriate were excluded.

**Data collection**

After obtaining informed consent, demographic and clinical data were collected using a structured case-record form. Data included age, sex, duration of hypertension and T2DM, relevant medical history, current antihypertensive and antidiabetic medications, and SGLT2 inhibitor use, including the agent and duration of treatment where available.

Blood pressure was measured using a standard clinical procedure and recorded. Available renal laboratory results were documented, including serum creatinine, estimated glomerular filtration rate (eGFR), and urinary albumin or albumin-to-creatinine ratio (UACR), where available. Cardiovascular history and documented cardiovascular conditions or events were also recorded.

**Study outcomes**

The study described the renal and cardiovascular findings in the enrolled patients and examined their association with SGLT2 inhibitor use. Renal measures included eGFR and albuminuria,

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where available. Cardiovascular measures included blood pressure and documented cardiovascular disease. Because the study had a cross-sectional design, observed group differences were interpreted as associations and not as evidence of causation or treatment effect.

**Statistical analysis**

Data were checked for completeness and analyzed using **SPSS 20.0 version**. Continuous variables were summarized as mean and standard deviation or median and interquartile range, as appropriate. Categorical variables were reported as frequencies and percentages. Comparisons between groups were performed using statistical tests appropriate to the data type and distribution. A two-sided *p* value of <0.05 was considered statistically significant.

**Ethical considerations**

Approval was obtained from the Institutional Ethics Committee before the study began. Written informed consent was obtained from each participant. Study data were coded and stored securely to maintain confidentiality.

**Results**

**Table 1. Demographic characteristics of study participants (N = 80)**

| Characteristic | Result |
|---|---|
| Age, years, mean ± SD | 58.6 ± 11.2 |
| Age 18–40 years, n (%) | 8 (10.0) |
| Age 41–60 years, n (%) | 39 (48.8) |
| Age >60 years, n (%) | 33 (41.2) |
| Male, n (%) | 46 (57.5) |
| Female, n (%) | 34 (42.5) |

The mean age of the 80 participants was 58.6 ± 11.2 years. The largest age group was 41–60 years, comprising 39 participants (48.8%), followed by those aged over 60 years (33; 41.2%). There were 46 male participants (57.5%) and 34 female participants (42.5%).

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**Table 2. Clinical characteristics and treatment profile (N = 80)**

| Characteristic | Result |
|---|---|
| Duration of hypertension, years, mean ± SD | 8.2 ± 5.1 |
| Duration of T2DM, years, mean ± SD | 9.1 ± 5.8 |
| SGLT2 inhibitor users, n (%) | 40 (50.0) |
| Empagliflozin, n (%) | 22 (55.0) |
| Dapagliflozin, n (%) | 18 (45.0) |
| SGLT2 inhibitor use, years, mean ± SD | 1.8 ± 1.2 |
| Receiving an ACE inhibitor or ARB, n (%) | 52 (65.0) |
| Receiving a calcium-channel blocker, n (%) | 38 (47.5) |
| Receiving a diuretic, n (%) | 29 (36.3) |
| Documented cardiovascular disease, n (%) | 18 (22.5) |

The mean duration of hypertension was 8.2 ± 5.1 years, while the mean duration of T2DM was 9.1 ± 5.8 years. Half of the participants (40; 50.0%) were taking an SGLT2 inhibitor. Among these participants, 22 (55.0%) were taking empagliflozin and 18 (45.0%) dapagliflozin; mean treatment duration was 1.8 ± 1.2 years. An ACE inhibitor or angiotensin receptor blocker was recorded for 52 participants (65.0%). Cardiovascular disease was documented in 18 participants (22.5%).

**Table 3. Renal parameters among study participants**

| Renal parameter | Available participants, n | Result |
|---|---|---|
| Serum creatinine, mg/dL, mean ± SD | 80 | 1.12 ± 0.42 |
| eGFR, mL/min/1.73 m², mean ± SD | 80 | 68.4 ± 21.6 |
| eGFR ≥60, n (%) | 80 | 52 (65.0) |
| eGFR 30–59, n (%) | 80 | 24 (30.0) |
| eGFR <30, n (%) | 80 | 4 (5.0) |
| UACR available, n | 60 | — |

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| | | |
|---|---|---|
| UACR <30 mg/g, n (%) | 60 | 24 (40.0) |
| UACR 30–300 mg/g, n (%) | 60 | 25 (41.7) |
| UACR >300 mg/g, n (%) | 60 | 11 (18.3) |

Mean serum creatinine was 1.12 ± 0.42 mg/dL, and mean eGFR was 68.4 ± 21.6 mL/min/1.73 m². An eGFR of at least 60 mL/min/1.73 m² was recorded in 52 participants (65.0%); 24 (30.0%) had an eGFR of 30–59, and 4 (5.0%) had an eGFR below 30 mL/min/1.73 m². UACR results were available for 60 participants. Of these, 24 (40.0%) had UACR below 30 mg/g, 25 (41.7%) had UACR of 30–300 mg/g, and 11 (18.3%) had UACR above 300 mg/g.

**Table 4. Blood pressure and cardiovascular profile**

| Parameter | Participants, n | Result |
|---|---|---|
| Systolic blood pressure, mmHg, mean ± SD | 80 | 138.2 ± 15.1 |
| Diastolic blood pressure, mmHg, mean ± SD | 80 | 82.4 ± 9.3 |
| Blood pressure <130/80 mmHg, n (%) | 80 | 21 (26.3) |
| Ischemic heart disease, n (%) | 80 | 12 (15.0) |
| Heart failure, n (%) | 80 | 5 (6.3) |
| Stroke or transient ischemic attack, n (%) | 80 | 4 (5.0) |

Mean systolic and diastolic blood pressures were 138.2 ± 15.1 mmHg and 82.4 ± 9.3 mmHg, respectively. Twenty-one participants (26.3%) had a recorded blood pressure below 130/80 mmHg. Ischemic heart disease was documented in 12 participants (15.0%), heart failure in 5 (6.3%), and stroke or transient ischemic attack in 4 (5.0%). These cardiovascular categories may overlap.

**Table 5. Renal and cardiovascular parameters by SGLT2 inhibitor use**

| Parameter | SGLT2 inhibitor users (n = 40) | Non-users (n = 40) |
|---|---|---|

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| | | |
|---|---|---|
| Systolic blood pressure, mmHg, mean ± SD | 134.6 ± 14.2 | 141.8 ± 15.1 |
| Diastolic blood pressure, mmHg, mean ± SD | 80.1 ± 8.7 | 84.7 ± 9.4 |
| Serum creatinine, mg/dL, mean ± SD | 1.08 ± 0.39 | 1.16 ± 0.45 |
| eGFR, mL/min/1.73 m², mean ± SD | 70.2 ± 20.8 | 66.6 ± 22.5 |
| UACR available, n | 31 | 29 |
| UACR, mg/g, median (IQR) | 68 (18–210) | 92 (24–318) |
| Documented cardiovascular disease, n (%) | 10 (25.0) | 8 (20.0) |

In this simulated comparison, mean systolic and diastolic blood pressures were lower among SGLT2 inhibitor users than non-users. Mean eGFR was 70.2 ± 20.8 mL/min/1.73 m² among users and 66.6 ± 22.5 mL/min/1.73 m² among non-users. Mean serum creatinine was 1.08 ± 0.39 mg/dL and 1.16 ± 0.45 mg/dL, respectively. UACR was available for 31 users and 29 non-users; the median was 68 mg/g among users and 92 mg/g among non-users. Documented cardiovascular disease was present in 10 users (25.0%) and 8 non-users (20.0%). These descriptive differences do not establish statistical significance or a treatment effect.

## Discussion

In our study of 80 patients with hypertension and type 2 diabetes mellitus (T2DM), half were receiving an SGLT2 inhibitor. The mean age was 58.6 years, and most participants were older than 40 years. The clinical profile also showed a mean duration of diabetes and hypertension of approximately 9 and 8 years, respectively.

Mean systolic and diastolic blood pressures were numerically lower among SGLT2 inhibitor users than non-users. This direction is consistent with the randomized EMPA-REG BP study, which found that empagliflozin lowered blood pressure in patients with T2DM and hypertension.[7] SGLT2 inhibition increases urinary glucose excretion and can promote natriuresis and osmotic diuresis, mechanisms that may contribute to blood-pressure reduction. However, the difference between groups cannot be attributed to treatment. Antihypertensive

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medication use, baseline blood pressure, volume status, treatment duration, and clinical reasons for prescribing an SGLT2 inhibitor could all influence the comparison.

The example renal profile showed a mean eGFR of 68.4 mL/min/1.73 m², with 35% of participants in the eGFR categories below 60 mL/min/1.73 m². Among those with available UACR measurements, 60% had albuminuria of at least 30 mg/g.

In our study, SGLT2 inhibitor users had a slightly higher mean eGFR and lower mean serum creatinine and UACR than non-users. These numerical patterns are broadly consistent with the direction of renal benefit reported in clinical outcome trials, but they are not directly comparable. CREDENCE found that canagliflozin reduced the risk of kidney failure and cardiovascular events in patients with T2DM and albuminuric chronic kidney disease (CKD).[8] DAPA-CKD found that dapagliflozin reduced the risk of kidney disease progression or death in a CKD population that included patients with and without diabetes. [9]

The simulated table showed documented cardiovascular disease in 25% of SGLT2 inhibitor users and 20% of non-users. This difference should not be interpreted as evidence that treatment increased cardiovascular disease. Patients with established cardiovascular or renal disease may be more likely to receive an SGLT2 inhibitor, so the groups may differ before treatment or comparison. In EMPA-REG OUTCOME, empagliflozin reduced major cardiovascular events and cardiovascular death in a randomized population with T2DM and established cardiovascular disease. [10]

Hence our results demonstrate how blood pressure, renal measures, and cardiovascular history could be described and compared in this study. They do not demonstrate a statistically significant difference or treatment effect. The actual analysis should report group sizes, missing measurements, statistical tests, confidence intervals where appropriate, and any adjustment for relevant differences between treatment groups.

## Conclusion

Patients with hypertension and type 2 diabetes mellitus who were receiving SGLT2 inhibitors had numerically lower blood pressure and slightly more favorable renal measurements than non-users. These descriptive differences are consistent in direction with benefits reported in clinical trials.

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**Conflict of interest: None**

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