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Glycine Volume and TURP Syndrome During Monopolar Transurethral Resection of the Prostate: A Prospective Study

Yogiraj Malge[1], Ganesh Swami[2], Meghraj Chawada[3], Dhiraj Kumar Hedda[4]

[1]Postgraduate Resident, Department of General Surgery, Vilasrao Deshmukh Government Medical College, Latur, Maharashtra, India
Corresponding Author Email: *yogimalage11[at]gmail.com*

[2]Associate Professor, Department of General Surgery, Vilasrao Deshmukh Government Medical College, Latur, Maharashtra, India

[3]Associate Professor, Department of General Surgery, Vilasrao Deshmukh Government Medical College, Latur, Maharashtra, India

[4]Assistant Professor, Department of General Surgery, Vilasrao Deshmukh Government Medical College, Latur, Maharashtra, India

Abstract: ***Background**: Transurethral resection of the prostate (TURP) syndrome remains an uncommon but potentially life-threatening complication of monopolar TURP using hypotonic irrigation. **Objective**: To determine the incidence of TURP syndrome and evaluate its association with the volume of 1.5% glycine used during surgery. **Methods**: This prospective observational study included 384 men older than 50 years undergoing monopolar TURP for benign prostatic hyperplasia at a tertiary-care teaching hospital. Demographic, operative, biochemical and clinical variables were recorded. Associations were analysed using chi-square or Fisher exact tests, paired tests and Mann-Whitney U tests, with p<0.05 considered significant. **Results**: TURP syndrome occurred in 9 patients (2.34%). Mean serum sodium decreased from 139.93±2.40 to 136.90±3.47 mEq/L (p<0.001). Patients with TURP syndrome received more glycine (29.07±4.16 vs 19.99±2.80 L), had longer procedures (83.67±9.08 vs 50.27±11.92 min), more tissue resected (63.44±9.49 vs 23.96±8.69 g), and a greater sodium fall (15.42±4.36 vs 2.74±1.40 mEq/L); all p<0.001. Syndrome frequency rose from 0% with ≤20 L glycine to 100% with >30 L. **Conclusion**: Higher glycine use, prolonged surgery, larger glands, greater tissue resection and marked postoperative sodium decline identified patients at increased risk.***

Keywords: Benign prostatic hyperplasia; Glycine; Hyponatremia; Monopolar TURP; TURP syndrome

1. Introduction

Benign prostatic hyperplasia is a common age-related cause of lower urinary tract symptoms and bladder outlet obstruction. Transurethral resection of the prostate remains an effective surgical treatment for men with refractory symptoms, urinary retention or complications of obstruction [1-4]. Conventional monopolar TURP requires a non-conductive irrigant. Glycine 1.5% is inexpensive and provides satisfactory visibility, but systemic absorption through opened prostatic venous sinuses can cause acute intravascular expansion, dilutional hyponatremia, hypo-osmolality and glycine-related neurological or cardiovascular toxicity [5-9]. Classical TURP syndrome may present with nausea, confusion, visual disturbance, seizures, bradycardia, hypertension, hypotension, pulmonary edema or cardiovascular collapse. Its risk is influenced by irrigation pressure, capsular perforation, gland size, bleeding, operative duration and the amount of tissue resected [8-12]. Although bipolar saline-based techniques have reduced the incidence of classical TURP syndrome, monopolar TURP remains widely used in resource-constrained settings. Measuring the total volume of glycine used does not directly quantify systemic absorption, but it is a practical marker of irrigation exposure and procedural complexity.

This study assessed the incidence and clinical profile of TURP syndrome in patients undergoing monopolar TURP and examined its relationship with glycine volume, operative duration, prostate size, tissue resection and perioperative serum sodium changes.

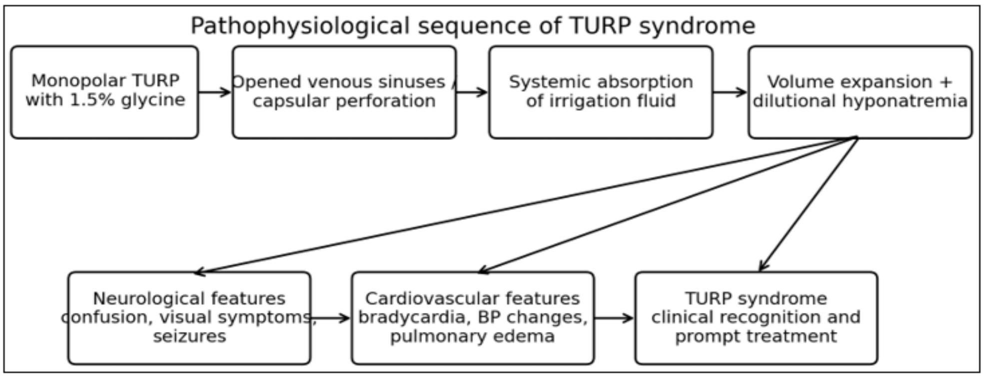

Figure 1: Pathophysiological sequence leading to TURP syndrome

2. Literature Survey

Early physiological studies established that absorption of electrolyte-free irrigants during TURP produces plasma dilution and may cause symptomatic hyponatremia, particularly when absorption is rapid or exceeds approximately 1-2 L [5-8]. Glycine also has irrigant-specific effects, including visual and neurological manifestations, so the syndrome cannot be explained by sodium dilution alone [7,8]. Large complication series and reviews identify prolonged resection, high irrigation pressure, venous sinus exposure, capsular perforation and large prostate volume as important risk factors [3,9,10].

Randomized trials and meta-analyses comparing monopolar and bipolar TURP have shown broadly comparable functional efficacy, while bipolar systems using normal saline reduce serum sodium decline and the risk of classical TURP syndrome [13-17]. Nevertheless, where monopolar TURP continues to be performed, systematic monitoring of irrigation exposure and electrolytes remains clinically relevant.

3. Problem Definition

The total volume of glycine used during monopolar TURP is routinely visible to the operating team, but its relationship with clinically evident TURP syndrome is not always quantified in institutional practice. Local data were required to identify clinically useful exposure thresholds and associated operative or biochemical risk markers.

4. Methodology / Approach

Study design and setting: A prospective observational study was conducted over 18 months in the Department of General Surgery of a tertiary-care teaching hospital. The study enrolled 384 male patients diagnosed with benign prostatic hyperplasia who underwent monopolar TURP using 1.5% glycine.

Eligibility: Men older than 50 years with clinically and radiologically diagnosed benign prostatic hyperplasia planned for monopolar TURP were included after written informed consent. Exclusion criteria included suspected or confirmed prostate cancer, previous prostate surgery, urethral stricture, bladder malignancy or calculus, neurogenic bladder, preoperative dyselectrolytemia, severe renal impairment, uncontrolled cardiac disease, conversion or abandonment of TURP, and incomplete records.

Data collection: Age, presentation, comorbidities, ASA grade, prostate size, preoperative hemoglobin, creatinine and electrolytes were recorded. Intraoperative variables included surgery duration, tissue resected, glycine volume, bleeding and capsular perforation. Postoperative sodium and potassium, cardiovascular and neurological manifestations, severity, management and hospital stay were documented. TURP syndrome was diagnosed from compatible perioperative clinical manifestations accompanied by biochemical and fluid-related disturbance.

Ethics: Institutional Ethics Committee approval was obtained before study commencement. Participation was voluntary, written informed consent was obtained, and coded identifiers were used to preserve confidentiality.

Statistical analysis: Categorical variables were summarized as frequencies and percentages and analysed using chi-square or Fisher exact tests. Quantitative variables were summarized using mean, standard deviation, median and range. Paired preoperative-postoperative electrolyte comparisons and between-group comparisons were performed using appropriate parametric or non-parametric tests. Spearman correlation was used for operative variables and sodium decline. A p-value below 0.05 was considered statistically significant.

5. Results and Discussion

Participant and operative profile

All 384 participants were male. Mean age was 67.00±6.91 years and mean prostate size was 58.05±14.52 g. The mean operative duration was 51.06±12.88 minutes, mean tissue resected was 24.89±10.55 g and mean glycine volume used was 20.21±3.15 L.

Variable	Mean ± SD	Median	Range
Age (years)	67.00 ± 6.91	66.00	51-86
Prostate size (g)	58.05 ± 14.52	58.00	32-117
Preoperative sodium (mEq/L)	139.93 ± 2.40	139.90	136-144
Creatinine (mg/dL)	1.10 ± 0.26	1.09	0.70-1.99
Surgery duration (min)	51.06 ± 12.88	50.00	25-96
Tissue resected (g)	24.89 ± 10.55	23.00	12-73
Glycine used (L)	20.21 ± 3.15	20.20	11.90-34.30

Incidence, severity and biochemical change

TURP syndrome occurred in 9 of 384 patients, an incidence of 2.34%. Mild, moderate and severe syndrome each occurred in three patients. Mean serum sodium decreased by 3.03 mEq/L after surgery, while the potassium change was not statistically significant.

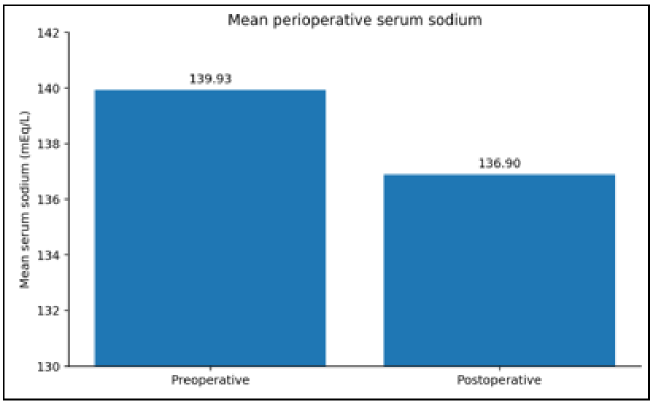

Figure 2: Mean preoperative and postoperative serum sodium concentrations

Outcome	n	%
No TURP syndrome	375	97.66
TURP syndrome	9	2.34
Mild	3	0.78
Moderate	3	0.78
Severe	3	0.78

Electrolyte	Preoperative mean ± SD	Postoperative mean ± SD	Mean change	p-value
Sodium (mEq/L)	139.93 ± 2.40	136.90 ± 3.47	3.03	<0.001
Potassium (mEq/L)	4.21 ± 0.34	4.23 ± 0.37	0.02	0.068

Glycine exposure and TURP syndrome

A clear dose-gradient was observed across glycine categories. No patient developed TURP syndrome when glycine use was ≤20 L. Incidence increased to 1.10% with 20.1-25 L, 27.27% with 25.1-30 L and 100% when >30 L was used (p<0.001). This categorical relationship was stronger than the weak continuous correlation between glycine volume and sodium decline (Spearman r=0.095, p=0.062), suggesting a threshold effect rather than a simple linear relationship across the entire cohort.

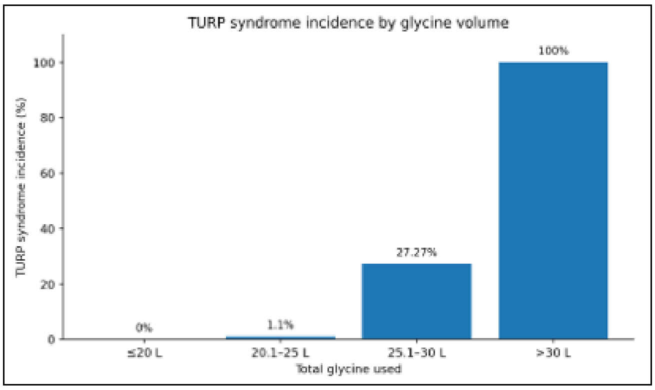

Figure 3: TURP syndrome incidence increased sharply when glycine use exceeded 25 L.

Glycine used	Total	TURP syndrome, n (%)	No syndrome, n (%)
≤20 L	188	0 (0.00)	188 (100.00)
20.1-25 L	181	2 (1.10)	179 (98.90)
25.1-30 L	11	3 (27.27)	8 (72.73)
>30 L	4	4 (100.00)	0 (0.00)

Other risk factors

TURP syndrome clustered in older patients, larger glands, prolonged procedures and larger resections. No case occurred in procedures lasting ≤60 minutes, whereas 58.33% of procedures lasting >75 minutes were complicated by the syndrome. Similarly, no case occurred when ≤40 g of tissue was resected; all six patients with >60 g resected developed TURP syndrome. Both patients with capsular perforation developed the syndrome, and all three patients with significant bleeding were affected.

Risk factor category	TURP syndrome, n/total (%)	p-value
Age >80 years	4/15 (26.67)	<0.001
ASA III	5/80 (6.25)	0.024
Prostate size >80 g	8/19 (42.11)	<0.001
Surgery duration >75 min	7/12 (58.33)	<0.001
Tissue resected >60 g	6/6 (100.00)	<0.001
Capsular perforation	2/2 (100.00)	<0.001
Significant bleeding	3/3 (100.00)	<0.001
Postoperative sodium <125 mEq/L	6/6 (100.00)	<0.001
Sodium fall >15 mEq/L	5/5 (100.00)	<0.001

Comparison of patients with and without TURP syndrome

Variable	No TURP syndrome (n=375)	TURP syndrome (n=9)	p-value
Age (years)	66.70 ± 6.68	79.67 ± 3.67	<0.001
Prostate size (g)	57.07 ± 13.04	99.11 ± 13.99	<0.001
Creatinine (mg/dL)	1.09 ± 0.25	1.38 ± 0.31	0.003
Surgery duration (min)	50.27 ± 11.92	83.67 ± 9.08	<0.001
Tissue resected (g)	23.96 ± 8.69	63.44 ± 9.49	<0.001
Glycine used (L)	19.99 ± 2.80	29.07 ± 4.16	<0.001
Postoperative sodium (mEq/L)	137.20 ± 2.79	124.28 ± 5.18	<0.001
Fall in sodium (mEq/L)	2.74 ± 1.40	15.42 ± 4.36	<0.001
Hospital stay (days)	2.71 ± 0.78	5.11 ± 1.62	<0.001

The syndrome incidence of 2.34% is comparable to contemporary reports of clinically evident TURP syndrome and lower than many historical series [9-12,18]. The marked differences in operative duration, tissue resection, glycine exposure and postoperative sodium support the established mechanism of irrigant absorption through opened venous channels. The observed threshold above 25 L is clinically useful but should not be interpreted as a universal safe limit, because total irrigant used is not equivalent to absorbed volume and is confounded by operative complexity.

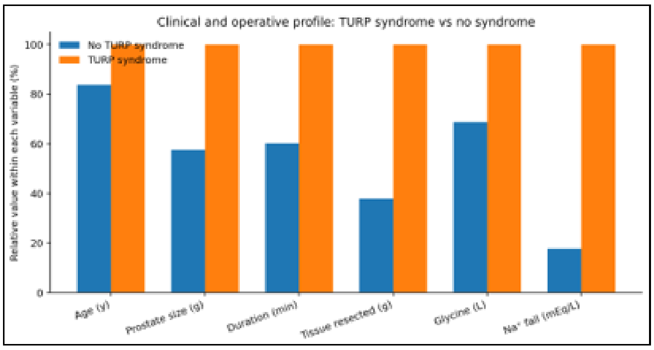

Figure 4: Relative clinical and operative differences between patients with and without TURP syndrome

Advanced age and ASA III status likely reflect reduced physiological reserve. The very strong associations with capsular perforation and significant bleeding are biologically plausible because both increase exposure of venous or extravascular pathways to irrigation fluid. The weak overall correlation between glycine volume and sodium decline illustrates that absorption depends on pressure, venous sinus exposure, bleeding and capsular integrity, not volume alone. These findings reinforce the safety rationale for saline-based bipolar TURP reported in randomized studies and meta-analyses [13-17]. Where monopolar TURP is used, teams should track cumulative glycine volume, minimize irrigation pressure, control bleeding early, avoid prolonged resection, assess sodium promptly when exposure is high, and maintain a low threshold for stopping the procedure in high-risk patients.

6. Conclusion

TURP syndrome occurred in 2.34% of patients undergoing monopolar TURP with 1.5% glycine. Higher glycine volume, prolonged surgery, larger prostate size, greater tissue resection, capsular perforation, significant bleeding and marked postoperative sodium decline were strongly associated with the syndrome. Monitoring cumulative glycine use together with operative duration and serum sodium provides a practical early-warning strategy. Prompt recognition and severity-based treatment can reduce morbidity.

7. Future Scope

Future multicentre studies should directly measure absorbed irrigation volume, record irrigation pressure and fluid-column height, and use multivariable modelling to distinguish independent risk factors. Comparative prospective studies of monopolar glycine TURP and bipolar saline TURP would clarify the incremental safety benefit in similar patient populations. Longer follow-up should examine renal, cardiovascular and functional outcomes.
Study limitations include the single-centre observational design, only nine TURP syndrome events, absence of direct measurement of glycine absorption, short-term outcome assessment, and no bipolar-TURP comparator.

8. Declarations

Ethics approval and consent to participate: Institutional Ethics Committee approval was obtained before study commencement. Written informed consent was obtained from all participants.

Consent for publication: Not applicable; no identifiable patient information is presented.

Funding: No external funding was reported.

Conflict of interest: The authors declare no conflict of interest.

Data availability: De-identified data are available from the corresponding author on reasonable request, subject to institutional and ethical requirements.

Author contributions: Yogiraj Malge contributed to study conduct, data collection, analysis and manuscript preparation. Ganesh Swami supervised the study, interpreted the findings and critically revised the manuscript.

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