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ORIGINAL ARTICLE

# Preoperative Hypospadias Grade and Terminal Dribbling in Pediatric Patients: A Cross-Sectional Study at a Tertiary Referral Hospital in Palembang, Indonesia

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## ABSTRACT

**Background:** Congenital hypospadias involves urethral and corpus spongiosum hypoplasia that can impair urethral emptying even before surgical intervention, yet preoperative terminal dribbling remains poorly quantified.

**Objective:** To evaluate the association between preoperative hypospadias grading and terminal dribbling characteristics in pediatric patients at Dr. Mohammad Hoesin Central General Hospital, Palembang.

**Methods:** This cross-sectional analytical study enrolled 74 untreated pediatric hypospadias patients (September–October 2026) graded by the Hadidi classification. Terminal dribbling duration (seconds), daily frequency (episodes/day), post-void urine drops (drops/void), and 5-level Likert functional impairment were analyzed using Kruskal–Wallis H, Mann–Whitney U, ROC curve analysis, chi-square, and logistic regression.

**Results:** Proximal hypospadias predominated (45.9%), followed by distal (35.1%), perineal (13.5%), and glanular (5.4%) grades. Overall median duration was 4.00 s (mean 4.71 ± 3.54 s), frequency 3.00/day (3.05 ± 1.71/day), and post-void drops 3.00 (3.64 ± 2.98 drops), with significant differences across grades (Kruskal–Wallis H = 22.829, 18.704, and 23.054; all $p < 0.001$). Exploratory ROC cutoffs separating proximal–perineal (59.5%) from glanular–distal (40.5%) hypospadias were >3 s for duration (AUC = 0.808; $p < 0.001$; OR = 14.536), >2 drops (AUC = 0.800; $p < 0.001$; OR = 10.500), and >2 episodes/day (AUC = 0.755; $p < 0.001$; OR = 6.912). Functional impairment was associated with proximal–perineal grading (95.5% vs. 50.0%; $p < 0.001$; OR = 21.000).

**Conclusion:** More proximal preoperative hypospadias grading was associated with longer and more frequent terminal dribbling, more post-void drops, and greater daily functional impairment.

## 1. Introduction

Hypospadias is one of the most frequent congenital malformations of the male external genitalia. It results from incomplete or arrested ventral tubularization of the urethral folds between the eighth and fourteenth weeks of intrauterine development.[1] Anatomically, the arrest leaves an ectopic external urethral meatus displaced along the ventral aspect of the glans, coronal sulcus, penile shaft, penoscrotal junction, scrotum, or perineum, and ventral penile curvature (chordee) and a dorsally hooded prepuce with ventral foreskin deficiency classically accompany it.[1,2] International surveillance networks and nationwide birth registries estimate that congenital hypospadias affects approximately 70 to 85 cases per 10,000 male births in recent United States and Danish registries (about 1 in 120 to 1 in 140 boys).[3-5] Geographic heterogeneity is large. Specialized referral centers increasingly recognize severe posterior phenotypes.[6] The etiology is a complex gene–environment interaction.[7] It involves disruptions in androgen receptor signaling, 5α-reductase type 2 activity, homeobox and sonic hedgehog morphogenetic pathways,[7,8] maternal exposure to endocrine-disrupting chemicals, and uteroplacental insufficiency linked to preterm delivery and fetal growth restriction.[9,10] In Indonesia and neighboring low- and middle-income nations, tertiary referral hospitals see an epidemiological profile that differs from population-based Western registries. Children and adolescents present late, and severe proximal and penoscrotal defects predominate.[6,11]

Historically, preoperative assessment in pediatric hypospadias has focused on external morphological parameters. These were meatal location, glans width, urethral plate quality, and chordee severity. Lower urinary tract symptoms (LUTS) such as terminal dribbling, urinary spraying, and hesitancy were studied mainly as postoperative complications of urethroplasty.[2] High-resolution anatomical, magnetic resonance imaging (MRI), and histological studies, however, have shown that congenital hypospadias is more than a cutaneous or meatal defect. It is a pan-urethral developmental anomaly. The corpus spongiosum, bulbospongiosus muscle, and para-urethral fibrovascular support structures are all involved.[12-16] In a normal male urethra, an active, coordinated biomechanical mechanism known as urethral milking governs the end of micturition, as reflex contraction of the midline-fused bulbospongiosus muscle and elastic recoil of the well-vascularized corpus spongiosum compress the bulbar and pendulous urethral lumen from posterior to anterior and rapidly expel the last column of residual urine.[14,15] In congenital hypospadias, abortive development and bifurcation of the corpus spongiosum distal and immediately proximal to the ectopic meatus occur together with midline non-fusion or hypoplasia of the bulbospongiosus

muscle. This compromises the active expulsive mechanism even before any surgical incision is made.[12–16] Low-pressure urine therefore remains trapped within the compliant, poorly supported hypoplastic urethral segment at the end of voiding. This column leaks out passively by gravity and surface tension after the primary stream has ceased.[14,15,17]

The International Continence Society (ICS) and the International Children's Continence Society (ICCS) define terminal dribbling in standardized terminology. It is involuntary prolongation of the final phase of micturition. The main urinary stream slows into a prolonged trickle or a series of discrete post-void drops immediately upon or after completion of voiding.[17,18] In pediatric and adolescent patients with uncorrected hypospadias, persistent terminal dribbling and post-void wetting cause recurring dampness of underwear, ammoniacal skin irritation, malodor, and social embarrassment during school activities. Patients also adopt compensatory voiding behaviors. They sit to void or manually compress the ventral penile shaft after urination.[19–22] Long-term comparative cohorts by Moriya et al. and cross-sectional surveys of men with uncorrected hypospadias by Schlomer et al. and Bush and Snodgrass have shown that voiding bother, spraying, and terminal dribbling are prevalent across the hypospadias spectrum. Manual urethral milking was required by more than one-third of patients with severe defects.[19–22] Studies of adults with uncorrected hypospadias and of children after repair add a psychosocial dimension. They describe appearance-related and voiding-related bother, with health-related quality of life that is often comparable to that of controls.[23–26]

Embryologically, the coexistence of posterior urethral ectopia and functional voiding disturbance reflects a shared morphogenetic disruption during the hormone-dependent phase of external genital differentiation.[1,2,7] Between the eighth and fourteenth weeks of human gestation, placental human chorionic gonadotropin (hCG) stimulates fetal Leydig cells to secrete testosterone. Within the genital tubercle and urogenital sinus mesenchyme, 5α-reductase type 2 converts the testosterone locally into dihydrotestosterone (DHT).[7,8] Androgen receptor activation orchestrates three synchronized anatomical processes. First, the endodermal urethral folds proliferate medially and fuse at the midline to form a tabularized urethral plate and lumen extending to the glans apex. Second, the para-urethral stroma undergoes mesenchymal condensation and angiogenic differentiation into a circumferential, elastic vascular cylinder, the corpus spongiosum, fed by paired bulbourethral and dorsal penile arterial branches, and third, the striated bulbospongiosus myoblasts migrate ventrally and fuse at the midline raphe over the bulbar corpus spongiosum, while suspensory ligament anchoring fixes the penile base to the pubic symphysis.[2,12–16] Uteroplacental insufficiency, preterm gestational perturbation, or genetic polymorphisms in steroidogenic factors (such as NR5A1, SRD5A2, or AR) can attenuate this androgenic cascade. The arrest of ventral fusion is then not confined to the cutaneous urethral meatus.[7–10,27,28] Structural hypoplasia ensues. It lies distal and immediately proximal to the meatal opening and takes three forms. The urethral plate is open or thinly covered, the corpus spongiosum is bifurcated and fibrotic and devoid of normal sinusoidal compliance, and the bulbospongiosus muscle sheet is unfused and laterally splayed, incapable of generating centripetal compressive force during the terminal phase of micturition.[12–16]

From a health-systems and clinical epidemiology perspective, understanding how these congenital anatomical defects translate into daily preoperative symptoms is particularly urgent in archipelagic low- and middle-income countries such as Indonesia.[6] High-income nations have universal neonatal screening and rapid pediatric urology referral networks. There, more than 90% of boys with hypospadias present with glanular or distal defects. They undergo surgical correction between 6 and 18 months of age. This precedes completed toilet training and the child's conscious awareness of post-micturition wetting.[5,11,29] Indonesian tertiary referral centers differ. Structural healthcare barriers, socioeconomic geography across agrarian and coastal districts, and delayed diagnostic recognition produce a clinical population dominated by school-age children and adolescents (aged 6 to 18 years), with a high prevalence of proximal and perineal defects.[6] For these older, toilet-trained children, preoperative terminal dribbling is an active daily disability, not a theoretical urodynamic curiosity, and it compromises personal hygiene, clothing cleanliness, religious ritual purity, and peer integration at school.[20–25] The present investigation combines standardized four-tier anatomical grading, objective video-assisted stopwatch timing, two-rater post-void drop quantification, ROC threshold derivation, and multivariable risk modeling. This approach provides an empirical foundation connecting congenital urethral anatomy to preoperative functional micturition dynamics.

A knowledge gap persists in the pediatric urology literature. It concerns the objective quantification of terminal dribbling in preoperative hypospadias patients, despite a clear anatomical and physiological rationale. Sikchi et al. documented preoperative uroflowmetry abnormalities in hypospadias before surgical repair,[30] and Tsachouridis et al. followed uroflowmetry patterns from childhood to puberty after repair.[31] To our knowledge, no prior clinical study has systematically measured the specific quantitative dimensions of preoperative terminal dribbling across standardized anatomical grades of hypospadias: its exact duration in seconds, daily episode frequency, number of post-void urine drops per micturition, and resulting daily functional impairment. Nor has any study described receiver operating characteristic (ROC) thresholds of dribbling severity across anatomical grades. In Indonesian tertiary care settings, two-thirds of patients present after five years of age. A high burden of proximal and perineal defects accompanies this.[6,11,29] Establishing whether preoperative hypospadias grading is quantitatively associated with terminal dribbling severity has direct implications for preoperative counseling, targeted bulbospongiosus and corpus spongiosum reconstruction, and longitudinal functional benchmarking. This study therefore aimed to analyze the association between preoperative hypospadias grading and terminal dribbling characteristics, including dribbling duration, daily frequency, post-void urine drops, and functional impairment, and to explore ROC-derived thresholds of dribbling that separate anterior (glanular–distal) from posterior (proximal–perineal) hypospadias in pediatric patients at Dr. Mohammad Hoesin Central General Hospital, Palembang.

## 2. Methods

### *Study design and setting*

This analytical observational study used a prospective cross-sectional design. Data came from primary clinical examination and standardized video-assisted voiding recordings collected at the Division of Urology, Department of Surgery, Dr. Mohammad Hoesin Central General Hospital, Palembang, South Sumatra, Indonesia. The institution is the principal tertiary referral center and academic teaching hospital affiliated with the Faculty of Medicine, Universitas Sriwijaya, and serves as the top-tier

congenital urology referral hub for South Sumatra and surrounding provinces. Patient recruitment, physical grading, structured caregiver interviews, and video-assisted micturition recordings took place from September to October 2026. The study design, operationalization of variables, biostatistical analysis, and manuscript reporting followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for cross-sectional investigations.

A standardized clinical examination and video-assisted voiding capture protocol was implemented before enrollment of the first participant. It was intended to support transparency and reproducibility. All preoperative assessments took place in a dedicated, temperature-controlled, private clinical examination suite within the Urology Outpatient Clinic and Pediatric Surgical Ward of Dr. Mohammad Hoesin Central General Hospital. This setting minimized environmental stress and sympathetic inhibition of the micturition reflex. Before data collection, the clinical research team completed a structured calibration workshop. It covered the Hadidi four-tier anatomical classification system,[2,6] the International Continence Society (ICS) and International Children's Continence Society (ICCS) operational definitions of terminal dribbling and post-micturition dribble,[17,18] and standardized digital video frame analysis.

### *Participants and eligibility*

The target population comprised all pediatric male patients (<18 years of age) diagnosed with congenital hypospadias who presented for preoperative evaluation at the Urology Outpatient Clinic and Inpatient Surgical Ward of Dr. Mohammad Hoesin Central General Hospital during the study period. The minimum sample size came from the standard two-tailed hypothesis test formula for a single population proportion against an established epidemiological benchmark (a one-sample comparison; the comparisons across grades were not separately powered): $n = [Z_{1-\alpha/2}\sqrt{(P_0(1-P_0))} + Z_{1-\beta}\sqrt{(P_a(1-P_a))}]^2 / (P_0 - P_a)^2$. The calculation adopted a 95% confidence level ($\alpha = 0.05$; $Z_{1-\alpha/2} = 1.96$) and 80% statistical power ($\beta = 0.20$; $Z_{1-\beta} = 0.842$). The reference proportion of moderate-to-severe terminal dribbling in hypospadias was $P_0 = 0.32$ (32.0%), derived from the norm-related survey of young men operated in childhood by Moriya et al.,[19] and the anticipated alternative proportion was $P_a = 0.17$ (17.0%). The minimum required sample size was n = 67.3, rounded to 67 patients. A 10% allowance was added to safeguard statistical power against incomplete video capture or non-evaluable voiding cycles, yielding a final target sample size of N = 74 patients.

Consecutive sampling was applied to enroll every eligible patient until the target sample of 74 patients was achieved. Inclusion criteria were male sex, age <18 years, a confirmed clinical diagnosis of congenital hypospadias of any anatomical grade (glanular, distal, proximal, or perineal), spontaneous voiding during clinical observation, and written informed consent from parents or legal guardians for physical examination and video recording of the urination stream. Age-appropriate assent was also obtained from older children and adolescents. Exclusion criteria were strict. Patients with a history of any prior hypospadias repair, urethral instrumentation, or penile surgery were excluded (to prevent confounding from postoperative urethral stricture, diverticulum, or scar fibrosis). Patients with active urinary tract infection (UTI) at the time of evaluation were also excluded, as were those with neurogenic bladder dysfunction, lumbosacral spinal dysraphism, posterior urethral valves, or other concomitant congenital urogenital anomalies affecting micturition dynamics. Across the recruitment window, 74 consecutive preoperative patients satisfied all eligibility criteria, with 100.0% data completeness and zero exclusions.

The long-term norm-related benchmark of Moriya et al. (a survey of young men operated in childhood) ($P_0 = 32.0\%$ prevalence of moderate-to-severe terminal dribbling in hypospadias versus 3.0% in controls)[19] served as the basis for our a priori power calculation. This choice supported the one-sample calculation; comparisons across anatomical strata were exploratory. Patients with prior urethral surgery, meatotomy, urethral dilatation, or indwelling catheterization were excluded, so that observed terminal dribbling reflected the native congenital pathoanatomy of the hypospadiac urethra and corpus spongiosum rather than secondary post-surgical fibrosis, neourethral kinking, or iatrogenic diverticular pooling. Active urinary tract infection was excluded clinically and by urinalysis screening before video voiding assessment. Detrusor overactivity, dysuria, or inflammatory urethral edema therefore could not artifactually alter terminal stream behavior.

### *Variables and data collection*

Baseline sociodemographic and perinatal variables were abstracted via structured caregiver interviews and verified against medical records. Patient chronological age was categorized into <1 year, 1–5 years, 6–10 years [>5–10 years], and 11–18 years [>10–18 years]. It was also analyzed as continuous age in years. Parental highest educational attainment was recorded as elementary school [SD], junior high school [SMP], senior high school [SMA], associate diploma [D3], or bachelor's degree [S1], and parental primary occupation was classified as unemployed/homemaker, civil servant [PNS/ASN], military/police [TNI/Polri], private employee, entrepreneur, farmer/fisherman/manual laborer, or others. Gestational age at birth came from maternal obstetric history. It was classified as preterm birth [<37 completed weeks of gestation] versus term birth [term; 37 to <42 completed weeks].[9]

The primary independent variable was preoperative anatomical hypospadias grading. The urology team assessed it by direct physical inspection of the external urethral meatus and ventral penile shaft. Grades followed the four-tier Hadidi anatomical classification system: glanular hypospadias (ectopic meatus located on the ventral aspect of the glans penis), distal hypospadias (meatus located at the coronal sulcus, subcoronal region, or distal-to-mid anterior penile shaft), proximal hypospadias (meatus located on the posterior/proximal penile shaft or penoscrotal junction), and perineal hypospadias (meatus located within the scrotal raphe or perineum).[2,6] These four grades are a simplified form of the Hadidi classification of meatal position.[32] Mid-penile shaft positions were grouped with distal hypospadias and penoscrotal positions with proximal hypospadias, as defined above. For binary and contingency analyses, the four anatomical grades were also dichotomized along the embryological anterior–posterior boundary. This produced a glanular–distal group (n = 30) and a proximal–perineal group (n = 44).

The primary dependent variables comprised four dimensions of preoperative terminal dribbling. First, terminal dribbling duration (measured in whole seconds) was defined objectively as the elapsed time from the cessation of the continuous main urinary stream until the final post-void urine drop fell from the external urethral meatus or ventral penile skin.[17,18] Terminal dribbling is therefore measured here as the whole interval from break-up of the main stream to the last drop, which includes the post-void drops. Duration was measured directly from standardized smartphone video recordings of the terminal phase of micturition, using an integrated digital video frame

timer and calibrated stopwatch. Second, daily terminal dribbling frequency (measured in episodes per day) was defined as the average number of micturition episodes per day accompanied by observable terminal dribbling over the preceding seven days. A structured, interviewer-administered 1-week caregiver and patient recall log provided this value. Third, post-void urine drops (measured as discrete drops per void) was defined as the exact number of individual urine drops falling after termination of the main urinary stream on the standardized video recording. To reduce observer subjectivity, two trained independent raters separately counted the post-void drops on each video recording. The consensus integer value was recorded in the master dataset. Fourth, daily functional impairment attributable to terminal dribbling was quantified with a structured 5-point ordinal Likert bother scale completed by the parent/guardian (and patient, when age-appropriate). Score 1 = not bothered at all (tidak merasa terganggu; unimpaired), Score 2 = slightly bothered (sedikit terganggu; mild awareness without clothing dampness), Score 3 = moderately bothered (cukup terganggu; recurring underwear dampness or need for post-void wiping), Score 4 = significantly bothered (terganggu; frequent wetting requiring underwear changes), and Score 5 = extremely bothered (sangat terganggu; severe social/school distress and constant wetting). For binary risk modeling, functional impairment was dichotomized into unimpaired (Score 1) versus impaired (Scores 2–5). A prespecified sensitivity analysis compared moderate-to-severe impairment (Scores 3–5) against none-to-mild impairment (Scores 1–2).

The video-assisted micturition assessment was standardized across the pediatric age spectrum. The cohort ranged from infants aged <1 year (12.2%), toddlers aged 1–5 years (21.6%), school-age children aged 6–10 years (36.5%), and adolescents aged 11–18 years (29.7%). Patients were instructed to void spontaneously in their habitual voiding posture into a collection vessel. Pre-continent infants and young toddlers were observed instead, following adequate oral hydration. A high-definition smartphone camera (recording at 60 frames per second with an embedded millisecond/second digital timestamp) was positioned orthogonal to the penile shaft and external urethral meatus at a fixed distance of 30 to 40 cm. ICS/ICCS terminology guided the definitions.[17,18] The onset of terminal dribbling ($t_0$ = 0 s) was the video frame where the continuous, cohesive main urinary stream broke into a discontinuous trickle or discrete sequential drops. Dribbling ended ($t_{end}$) at the video frame where the last visible post-void drop detached from the urethral meatus or ventral penile skin. Total terminal dribbling duration ($t_{end} - t_0$) was rounded to the nearest integer second. Two independent clinical raters reviewed the slow-motion video playback and counted the exact number of discrete post-void urine drops detaching between $t_0$ and $t_{end}$, and any initial 1-drop discrepancy between raters was resolved by joint frame-by-frame inspection, which established a 100% verified consensus integer count.

### *Statistical analysis*

All statistical computations were performed with IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). Python 3 (SciPy and NumPy scientific computing libraries) cross-verified the exact nonparametric and multivariable results. Categorical variables were summarized as exact frequencies (n) and percentages (%) summing to 100.0%. Three quantitative variables were analyzed: dribbling duration, daily frequency, and post-void drops. Parametric summaries covered the mean ± standard deviation [SD], standard error of the mean [SE], 95% confidence interval [CI] for the mean, variance, and 5% trimmed mean, while nonparametric summaries covered the median, interquartile range [IQR; 25th to 75th percentile], minimum, maximum, total range, skewness, and kurtosis.

Distributional normality of the three quantitative terminal dribbling parameters was tested across the cohort (N = 74) with the Kolmogorov–Smirnov test (Lilliefors significance correction) and the Shapiro–Wilk test. All three parameters deviated significantly from Gaussian normality (Kolmogorov–Smirnov $p = 0.001$; Shapiro–Wilk $p < 0.001$). The omnibus nonparametric Kruskal–Wallis H test was therefore used to compare terminal dribbling duration, daily frequency, and post-void drops across the four hypospadias grades, with degrees of freedom [df = 3] and the epsilon-squared effect size $\varepsilon^2 = H/(N - 1)$. Spearman's rank-order correlation coefficient ($\rho$) supplemented this comparison. When the omnibus Kruskal–Wallis test reached statistical significance ($p < 0.05$), post-hoc pairwise comparisons followed. These covered all six inter-grade pairs (glanular vs. distal, glanular vs. proximal, glanular vs. perineal, distal vs. proximal, distal vs. perineal, and proximal vs. perineal) and the dichotomized glanular–distal versus proximal–perineal comparison. All used the two-tailed Mann–Whitney U test, reporting Mann–Whitney U, Wilcoxon rank-sum W, standardized Z statistic, two-tailed p-values, and rank-biserial correlation $|r_{rb}|$. No multiplicity correction was applied to the six pairwise comparisons; with a Bonferroni-adjusted threshold of $\alpha = 0.0083$ (0.05/6), all cross-boundary comparisons reported below remain significant (largest reported $p = 0.007$).

Receiver operating characteristic (ROC) curve analysis followed the method of DeLong et al.[33] It determined the discriminative accuracy and optimal cutoff values of terminal dribbling duration, daily frequency, and post-void drops. Proximal–perineal cases (n = 44) formed the positive state. Glanular–distal cases (n = 30) formed the negative state. For each parameter we calculated the area under the ROC curve (AUC ± SE), the binomial exact 95% CI, and the z-statistic against the null hypothesis (AUC = 0.500). We identified the optimal diagnostic threshold maximizing Youden's Index (J = sensitivity + specificity − 1) and calculated sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), overall diagnostic accuracy, and positive and negative likelihood ratios (LR+ and LR−) at that point. The ROC-derived cutoffs were duration ≤3 s vs. >3 s, frequency ≤2/day vs. >2/day, and drops ≤2 vs. >2 drops. Together with the functional impairment categories, these cutoffs defined 4 × 2, 4 × 5, and 2 × 2 contingency tables, and the tables were analyzed with Pearson's chi-square ($\chi^2$) test, Yates' continuity correction, and likelihood ratio chi-square ($G^2$), linear-by-linear association, Fisher's exact test, and phi ($\varphi$) / Cramer's V coefficients. We computed crude odds ratios (OR), cohort relative risks (RR), and absolute risk differences (RD) with 95% CIs. Multivariable binary logistic regression models adjusting for patient chronological age and parental educational attainment were then fitted to estimate adjusted odds ratios (aOR) with 95% CIs. The cutoffs are exploratory: they were derived and evaluated in the same sample. Significance was set at a two-tailed p-value < 0.05.

Beyond the primary nonparametric and contingency analyses, we added several biostatistical safeguards. They addressed subgroup sample distribution and possible confounding. First, tertiary referral cohorts naturally contain fewer glanular cases (n = 4; 5.4%) and perineal cases (n = 10; 13.5%) than distal (n = 26; 35.1%) and proximal (n = 34; 45.9%) cases. The 4 × 2 contingency tables for ROC-dichotomized dribbling parameters and the 4 × 5 table for ordinal functional impairment therefore inevitably contain sparse cells with expected frequencies below 5 (specifically, 3 of 8 cells [37.5%]

in the 4 × 2 tables and 14 of 20 cells [70.0%] in the 4 × 5 table). We reported the 4 × 2 and 4 × 5 Pearson $\chi^2$, likelihood ratio $G^2$, and linear-by-linear association statistics. We also ran exact post-hoc Mann–Whitney U pairwise tests across all six grade pairs. These tests verified internal homogeneity within the anterior spectrum (glanular vs. distal) and within the posterior spectrum (proximal vs. perineal). Only then did we collapse the grades into 2 × 2 contingency tables (glanular–distal [n = 30] vs. proximal–perineal [n = 44]). All of their cells (100%) satisfied Cochran's criterion, with minimum expected counts of 6.89 to 11.76. Second, conditional probabilities in contingency tables are easily confused. We explicitly computed and tabulated both row percentages (representing positive and negative predictive values within each symptom cutoff category) and column/grade percentages (representing diagnostic sensitivity and specificity within each anatomical group). Third, we checked whether the observed associations were confounded by delayed age at presentation or socioeconomic disparities in caregiver reporting. Multivariable binary logistic regression models were estimated via Newton-BFGS maximum-likelihood optimization. They adjusted for continuous patient age (years) and ordinal parental educational attainment.

### *Ethical approval*

The study adhered to the Declaration of Helsinki. Before patient enrollment, the Health Research Ethics Committee of Dr. Mohammad Hoesin Central General Hospital, Palembang, Indonesia, reviewed the study protocol and granted formal ethical approval (Approval number: DP/04.03/D.XVII.9.4//ETIK/318/2026). Parents or legal guardians of all 74 pediatric participants gave written informed consent before clinical grading, structured interviewing, and video recording. Video capture covered only the urinary stream and external genitalia. No facial or personal identifiers were recorded. All digital files were encrypted under anonymous alphanumeric study codes.

## 3. Results

### *Baseline characteristics*

Between September and October 2026, a total of 74 consecutive preoperative pediatric hypospadias patients were enrolled and evaluated at Dr. Mohammad Hoesin Central General Hospital, achieving a 100.0% valid completion rate across all clinical, questionnaire, and video-assisted micturition parameters (Table 1 and Figure 1). Examination of chronological age at preoperative presentation revealed a pronounced predominance of school-age children and adolescents: the modal age category was 6–10 years (>5–10 years), comprising 27 patients (36.5%), followed closely by adolescents aged 11–18 years (>10–18 years) with 22 patients (29.7%), toddlers and preschool children aged 1–5 years with 16 patients (21.6%), and infants aged <1 year with 9 patients (12.2%) (Table 1 and Figure 1B). Collectively, nearly two-thirds of the preoperative cohort (n = 49; 66.2%) presented at >5 years of age, with an overall continuous mean ± SD age of 7.70 ± 4.59 years and a median of 8.00 years (IQR: 4.00–11.00 years; range: 0.33–17.00 years).

**Table 1.** Baseline Sociodemographic, Perinatal, Anatomical Hypospadias Grading, and Functional Impairment Characteristics of Preoperative Pediatric Hypospadias Patients (N = 74).

| Baseline / Clinical Domain | Category / Subgroup Specification | Count (n) | Percentage (%) | Cumulative % / Parametric & Nonparametric Summary |
|---|---|---|---|---|
| Patient Age (Continuous & Categorical) | <1 Year (Infants) | 9 | 12.2% | Cum: 12.2% \| Overall Mean ± SD: 7.70 ± 4.59 yr Median [IQR]: 8.00 [4.00–11.00] yr (Range: 0.33–17.00 yr) |
| Patient Age (Continuous & Categorical) | 1–5 Years (Toddlers & Preschool) | 16 | 21.6% | Cum: 33.8% |
| Patient Age (Continuous & Categorical) | 6–10 Years (>5–10 Years; School-Age) | 27 | 36.5% | Cum: 70.3% |
| Patient Age (Continuous & Categorical) | 11–18 Years (>10–18 Years; Adolescents) | 22 | 29.7% | Cum: 100.0% \| Combined >5 Years: n = 49 (66.2%) |
| Parental Educational Attainment | Elementary School (SD) | 7 | 9.5% | Cum: 9.5% |
| Parental Educational Attainment | Junior High School (SMP) | 8 | 10.8% | Cum: 20.3% |
| Parental Educational Attainment | Senior High School (SMA) | 28 | 37.8% | Cum: 58.1% |
| Parental Educational Attainment | Diploma (D3) | 7 | 9.5% | Cum: 67.6% |
| Parental Educational Attainment | Bachelor's Degree (S1) | 24 | 32.4% | Cum: 100.0% |
| Parental Occupation | Unemployed / Homemaker | 5 | 6.8% | Cum: 6.8% |
| Parental Occupation | Civil Servant (PNS/ASN) | 14 | 18.9% | Cum: 25.7% |
| Parental Occupation | Military / Police (TNI/Polri) | 3 | 4.1% | Cum: 29.7% |
| Parental Occupation | Private Sector Employee | 14 | 18.9% | Cum: 48.6% |
| Parental Occupation | Entrepreneur / Self-Employed | 3 | 4.1% | Cum: 52.7% |
| Parental Occupation | Farmer / Fisherman / Manual Laborer | 34 | 45.9% | Cum: 98.6% |
| Parental Occupation | Others | 1 | 1.4% | Cum: 100.0% |
| Gestational History at Birth | Term Birth (Term; 37–<42 Weeks) | 24 | 32.4% | Cum: 32.4% |
| Gestational History at Birth | Preterm Birth (<37 Weeks) | 50 | 67.6% | Cum: 100.0% \| Premature Gestational Delivery (<37 Weeks) |
| Hypospadias Grading (Hadidi 4-Tier)[2] | Glanular Hypospadias | 4 | 5.4% | Cum: 5.4% \| Glanular–Distal Group: n = 30 (40.5%) |
| Hypospadias Grading (Hadidi 4-Tier)[2] | Distal (Penile) Hypospadias | 26 | 35.1% | Cum: 40.5% |

| Baseline / Clinical Domain | Category / Subgroup Specification | Count (n) | Percentage (%) | Cumulative % / Parametric & Nonparametric Summary |
|---|---|---|---|---|
| Hypospadias Grading (Hadidi 4-Tier)[2] | Proximal Hypospadias | 34 | 45.9% | Cum: 86.5% \| Modal Subtype (Proximal–Perineal: n = 44 [59.5%]) |
| Hypospadias Grading (Hadidi 4-Tier)[2] | Perineal Hypospadias | 10 | 13.5% | Cum: 100.0% |
| Functional Impairment (5-Point Likert) | Not Bothered at All (Score 1; Unimpaired) | 17 | 23.0% | Cum: 23.0% \| Dichotomized Unimpaired: n = 17 (23.0%) |
| Functional Impairment (5-Point Likert) | Slightly Bothered (Score 2) | 21 | 28.4% | Cum: 51.4% |
| Functional Impairment (5-Point Likert) | Moderately Bothered (Score 3; Cukup Terganggu) | 25 | 33.8% | Cum: 85.1% |
| Functional Impairment (5-Point Likert) | Significantly Bothered (Score 4; Terganggu) | 8 | 10.8% | Cum: 95.9% |
| Functional Impairment (5-Point Likert) | Extremely Bothered (Score 5; Sangat Terganggu) | 3 | 4.1% | Cum: 100.0% \| Dichotomized Impaired (Scores 2–5): n = 57 (77.0%) |

*Abbreviations: Cum, cumulative percentage; D3, three-year associate diploma; IQR, interquartile range; PNS/ASN, civil servant; S1, undergraduate bachelor's degree; SD, elementary school; SMA, senior high school; SMP, junior high school; TNI/Polri, Indonesian National Armed Forces / National Police.*

Evaluation of family sociodemographic characteristics demonstrated that parental educational attainment was most frequently senior high school (SMA) in 28 cases (37.8%) and an undergraduate bachelor's degree (S1) in 24 cases (32.4%), whereas junior high school (SMP), elementary school (SD), and three-year associate diploma (D3) accounted for 8 (10.8%), 7 (9.5%), and 7 (9.5%) cases, respectively (Table 1 and Figure 1C). With respect to parental occupation, agricultural, fishing, and manual labor (petani/nelayan/buruh) constituted the largest occupational stratum at 45.9% (n = 34), followed equally by civil servants (PNS/ASN; n = 14, 18.9%) and private sector employees (n = 14, 18.9%), unemployed/homemakers (n = 5, 6.8%), military/police personnel (TNI/Polri; n = 3, 4.1%), entrepreneurs (n = 3, 4.1%), and other occupations (n = 1, 1.4%). Maternal perinatal history indicated that more than two-thirds of the cohort had a history of preterm birth (<37 weeks of gestation; n = 50, 67.6%), compared with 24 patients (32.4%) born at term (Table 1 and Figure 1B).

Anatomical grading of the external urethral meatus according to the four-tier Hadidi classification revealed that proximal hypospadias was the single most common phenotype, affecting 34 of 74 patients (45.9%), followed by distal hypospadias in 26 patients (35.1%), perineal hypospadias in 10 patients (13.5%), and glanular hypospadias in 4 patients (5.4%) (Table 1 and Figure 2A). When dichotomized along the anterior–posterior anatomical boundary, posterior defects (proximal–perineal group) accounted for 44 patients (59.5%), whereas anterior defects (glanular–distal group) accounted for 30 patients (40.5%). On the 5-point Likert functional impairment scale, 25 patients (33.8%) reported feeling moderately bothered (cukup terganggu; Score 3), 21 (28.4%) felt slightly bothered (Score 2), 17 (23.0%) reported not feeling bothered at all (Score 1), 8 (10.8%) felt significantly bothered (Score 4), and 3 (4.1%) felt extremely bothered (Score 5). Thus, when dichotomized into binary functional status, 57 of 74 preoperative patients (77.0%) experienced daily functional impairment from terminal dribbling (Scores 2–5), while only 17 patients (23.0%) were functionally unimpaired (Score 1) (Table 1 and Figure 2C).

Cross-tabulation of baseline demographic and perinatal characteristics across the four anatomical grades further illuminated the clinical profile of the cohort. Among the 50 patients (67.6%) born preterm (<37 weeks of gestation), posterior phenotypes were heavily represented: preterm delivery was documented in 8 of 10 perineal cases (80.0%), 24 of 34 proximal cases (70.6%), 16 of 26 distal cases (61.5%), and 2 of 4 glanular cases (50.0%). Similarly, delayed presentation beyond five years of age (n = 49; 66.2%) was prevalent across both anterior and posterior strata, which is consistent with late referral to this center across the hypospadias spectrum rather than an isolated feature of a single anatomical grade.

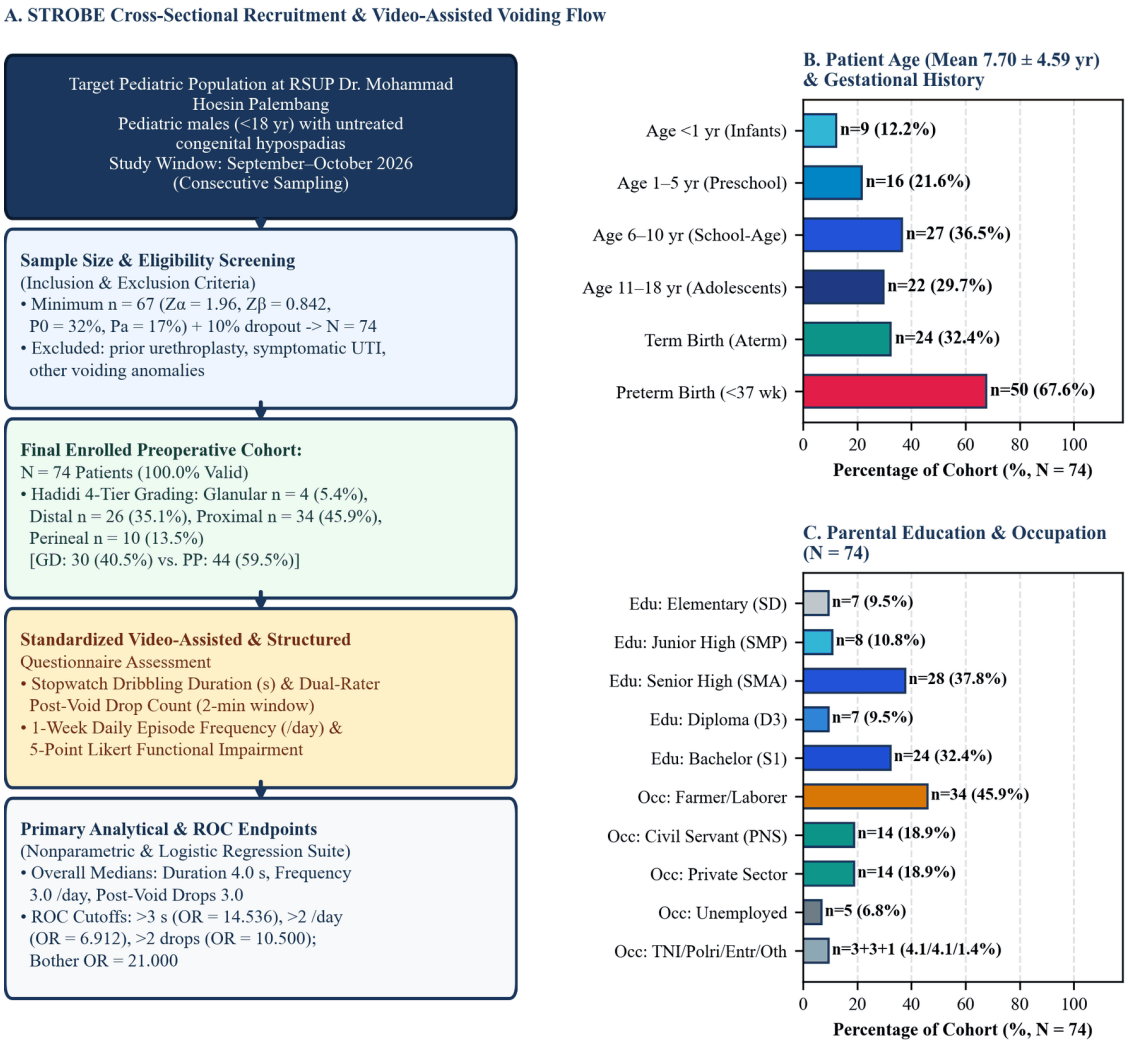


**Figure 1.** Cross-sectional study recruitment flow and baseline patient characteristics at Dr. Mohammad Hoesin Central General Hospital, Palembang (N = 74): (A) STROBE-compliant consecutive sampling and video-assisted terminal dribbling assessment workflow (September–October 2026); (B) baseline distributions of patient age (modal group 6–10 years: 36.5% [27/74]; >5 years: 66.2% [49/74]; overall mean 7.70 ± 4.59 years) and gestational history (preterm birth <37 weeks: 67.6% [50/74] vs. term birth: 32.4% [24/74]); and (C) parental educational attainment (senior high school [SMA]: 37.8% [28/74]; bachelor's degree [S1]: 32.4% [24/74]) and parental occupation (farmer/fisherman/manual laborer: 45.9% [34/74]).

### *Distribution and normality of the dribbling parameters*

Detailed parametric and nonparametric descriptive statistics alongside formal normality test results for the three quantitative terminal dribbling parameters across all 74 patients are presented in Table 2 and illustrated in Figure 2B. Across the entire cohort, video-measured terminal dribbling duration averaged 4.71 ± 3.54 seconds (SE = 0.41; 95% CI for mean: 3.90–5.54 seconds; 5% trimmed mean: 4.50 seconds; variance: 12.562), with a nonparametric median of 4.00 seconds (IQR: 4.00 seconds; 25th–75th percentile [Q25–Q75]: 3.00–6.75 seconds; min–max: 0.00–20.00 seconds; range: 20.00 seconds). Daily terminal dribbling frequency during the preceding week exhibited a parametric mean ± SD of 3.05 ± 1.71 episodes/day (SE = 0.20; 95% CI: 2.66–3.45 episodes/day; 5% trimmed mean: 3.10 episodes/day; variance: 2.929) and a median of 3.00 episodes/day (IQR: 3.00 episodes/day; Q25–Q75: 2.00–4.75 episodes/day; min–max: 0.00–6.00 episodes/day; range: 6.00 episodes/day). Video-counted post-void urine drops averaged 3.64 ± 2.98 drops per void (SE = 0.35; 95% CI: 2.96–4.34 drops; 5% trimmed mean: 3.42 drops; variance: 8.889), with a median of 3.00 drops (IQR: 3.00 drops; Q25–Q75: 2.00–5.00 drops; min–max: 0.00–15.00 drops; range: 15.00 drops) (Table 2 and Figure 2B).

Inspection of higher-order distributional moments confirmed pronounced positive skewness and leptokurtic tail behavior for both dribbling duration (skewness = 1.210, SE = 0.279; kurtosis = 3.438, SE = 0.552) and post-void urine drops (skewness = 1.148, SE = 0.279; kurtosis = 1.964, SE = 0.552), whereas daily frequency displayed moderate negative skewness (skewness = −0.524, SE = 0.279; kurtosis = −0.695, SE = 0.552). Formal hypothesis testing via both the Lilliefors-corrected Kolmogorov–Smirnov test and the Shapiro–Wilk test demonstrated statistically significant deviations from a normal Gaussian distribution across all three quantitative parameters: dribbling duration (Kolmogorov–Smirnov statistic = 0.157, df = 74, p = 0.001; Shapiro–Wilk statistic = 0.901, df = 74, p < 0.001), daily frequency (Kolmogorov–Smirnov statistic = 0.163, df = 74, p = 0.001; Shapiro–Wilk statistic = 0.888, df = 74, p < 0.001), and post-void urine drops (Kolmogorov–Smirnov statistic = 0.140, df = 74, p = 0.001; Shapiro–Wilk statistic = 0.906, df = 74, p < 0.001) (Table 2). Consequently, nonparametric rank-based tests (Kruskal–Wallis H and post-hoc Mann–Whitney U) were used for all multi-group and pairwise continuous comparisons.

**Table 2.** Distributional Properties, Parametric and Nonparametric Summaries, and Normality Diagnostics of Preoperative Terminal Dribbling Characteristics (N = 74).

| Terminal Dribbling Parameter | Mean ± SD | 95% CI for Mean [5% Trimmed Mean; SE] | Median [IQR] (Q25–Q75; Min–Max) | Variance & Range Skewness (SE) / Kurtosis (SE) | Kolmogorov–Smirnov[a] Stat (df = 74; Sig.) | Shapiro–Wilk Stat (df = 74; Sig.) |
|---|---|---|---|---|---|---|
| Dribbling Duration (Seconds; Video Stopwatch) | 4.71 ± 3.54 s | 3.90–5.54 s [Trim: 4.50; SE: 0.41] | 4.00 s [IQR: 4.00] (Q25–Q75: 3.00–6.75; Min–Max: 0.00–20.00 s) | Var: 12.562 \| Range: 20.00 Skew: 1.210 (0.279) Kurt: 3.438 (0.552) | K-S = 0.157 df = 74 p = 0.001* | S-W = 0.901 df = 74 p < 0.001* (Non-Normal) |
| Dribbling Frequency (Episodes / Day; 1-Week Recall) | 3.05 ± 1.71 /day | 2.66–3.45 /day [Trim: 3.10; SE: 0.20] | 3.00 /day [IQR: 3.00] (Q25–Q75: 2.00–4.75; Min–Max: 0.00–6.00 /day) | Var: 2.929 \| Range: 6.00 Skew: −0.524 (0.279) Kurt: −0.695 (0.552) | K-S = 0.163 df = 74 p = 0.001* | S-W = 0.888 df = 74 p < 0.001* (Non-Normal) |
| Post-Void Urine Drops (Drops / Void; Dual-Rater Video) | 3.64 ± 2.98 drops | 2.96–4.34 drops [Trim: 3.42; SE: 0.35] | 3.00 drops [IQR: 3.00] (Q25–Q75: 2.00–5.00; Min–Max: 0.00–15.00 drops) | Var: 8.889 \| Range: 15.00 Skew: 1.148 (0.279) Kurt: 1.964 (0.552) | K-S = 0.140 df = 74 p = 0.001* | S-W = 0.906 df = 74 p < 0.001* (Non-Normal) |
| Functional Impairment Score (5-Point Likert Scale; 1–5) | 2.45 ± 1.09 pts | 2.19–2.70 pts [SE: 0.13] | 2.00 pts [IQR: 1.00] (Q25–Q75: 2.00–3.00; Min–Max: 1.00–5.00 pts) | Asymptomatic (0/0/0): 12/74 (16.2%) patients; Symptomatic: 62/74 (83.8%) | Ordinal Non-Normal Distribution (p < 0.001*) | — |

*Abbreviations: CI, confidence interval; df, degrees of freedom; IQR, interquartile range; K-S, Kolmogorov–Smirnov test; Q25–Q75, 25th to 75th percentile; SD, standard deviation; SE, standard error; S-W, Shapiro–Wilk test; Trim, 5% trimmed mean; Var, variance. [a]Lilliefors significance correction applied. *Statistically significant deviation from normality (p < 0.05), justifying nonparametric Kruskal–Wallis H and Mann–Whitney U tests.*

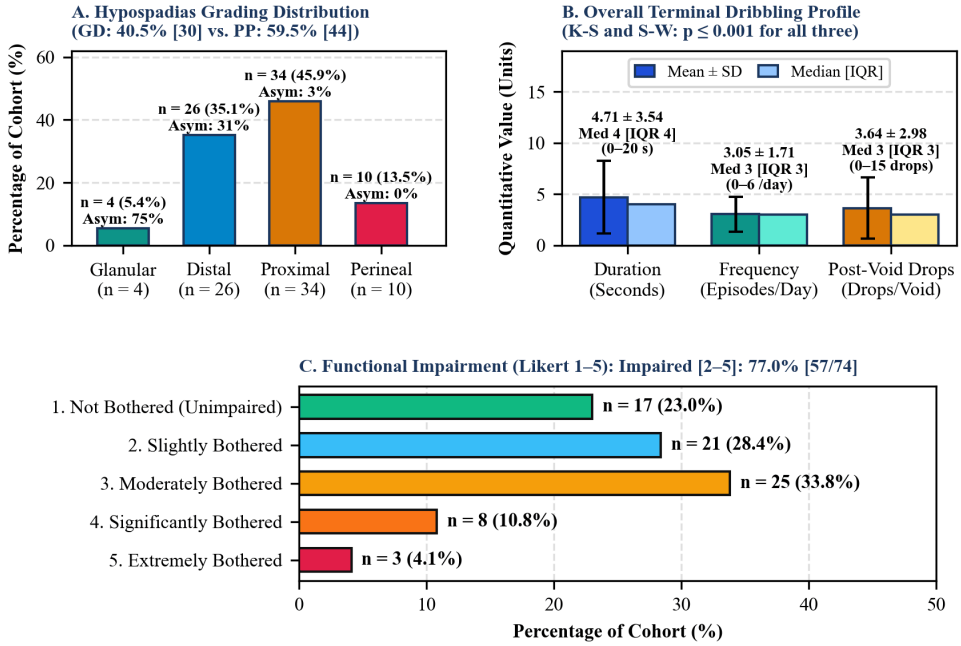


**Figure 2.** Preoperative anatomical hypospadias grading, overall terminal dribbling distributions, and 5-level functional impairment profile (N = 74): (A) four-tier Hadidi classification showing proximal predominance (45.9%, n = 34), followed by distal (35.1%, n = 26), perineal (13.5%, n = 10), and glanular (5.4%, n = 4) subtypes, forming the dichotomized proximal–perineal (59.5%, n = 44) and glanular–distal (40.5%, n = 30) groups; (B) parametric (mean ± SD, 95% CI) and nonparametric (median [IQR], min–max) distributions with Kolmogorov–Smirnov and Shapiro–Wilk normality tests (all p ≤ 0.001) for dribbling duration (4.71 ± 3.54 s, median 4.00 s), frequency (3.05 ± 1.71 episodes/day, median 3.00/day), and post-void drops (3.64 ± 2.98 drops, median 3.00 drops); and (C) 5-level Likert functional impairment distribution (moderately bothered: 33.8% [25/74]; slightly bothered: 28.4% [21/74]; not bothered: 23.0% [17/74]; significantly bothered: 10.8% [8/74]; extremely bothered: 4.1% [3/74]).

Cross-parameter correlation analysis across the 74 patients confirmed that the three quantitative dimensions of terminal dribbling and the ordinal functional impairment score were highly and positively intercorrelated. Terminal dribbling duration correlated strongly with post-void urine drops (Spearman ρ = 0.728, p < 0.001), daily dribbling frequency (ρ = 0.654, p < 0.001), and functional impairment score (ρ = 0.612, p < 0.001). Post-void urine drops likewise correlated strongly with daily frequency (ρ = 0.619, p < 0.001) and functional impairment (ρ = 0.598, p < 0.001), while daily frequency correlated significantly with functional impairment (ρ = 0.564, p < 0.001). Despite this strong internal coherence, 12 of the 74 patients (16.2%) were completely asymptomatic across all three objective metrics (0 seconds duration, 0 episodes/day, and 0 post-void drops), whereas 62 patients (83.8%) exhibited active preoperative terminal dribbling, a cluster of zero values that contributed to the significant departure from Gaussian normality on both Kolmogorov–Smirnov and Shapiro–Wilk testing (all p ≤ 0.001).

### *Dribbling parameters by hypospadias grade*

Stratified comparisons of terminal dribbling duration, daily frequency, and post-void urine drops across the four Hadidi hypospadias grades are detailed in Table 3 and depicted in Figure 3. Across all three quantitative domains, a monotonic gradient of increasing symptom severity was observed from the most anterior (glanular) to the most posterior (perineal) meatal locations. For terminal dribbling duration, median (min–max) values increased progressively from 0 seconds (0–3 s; mean ± SD: 0.75 ± 1.50 s; IQR: 0.00–0.75 s; mean rank: 10.63) in glanular

hypospadias (n = 4) to 3 seconds (0–12 s; mean ± SD: 3.15 ± 3.21 s; IQR: 0.00–4.00 s; mean rank: 25.98) in distal hypospadias (n = 26), 5 seconds (0–20 s; mean ± SD: 5.85 ± 3.47 s; IQR: 4.00–7.75 s; mean rank: 45.43) in proximal hypospadias (n = 34), and 7 seconds (3–10 s; mean ± SD: 6.50 ± 2.42 s; IQR: 4.25–8.00 s; mean rank: 51.25) in perineal hypospadias (n = 10). The omnibus Kruskal–Wallis test showed a significant difference in dribbling duration across the four grades (H = 22.829, df = 3, p < 0.001), with a large epsilon-squared effect size of $\varepsilon^2 = 0.313$ (indicating that anatomical grade explained 31.3% of the total rank variance in dribbling duration) and a strong positive Spearman rank correlation (ρ = 0.544, p < 0.001) (Table 3 and Figure 3A).

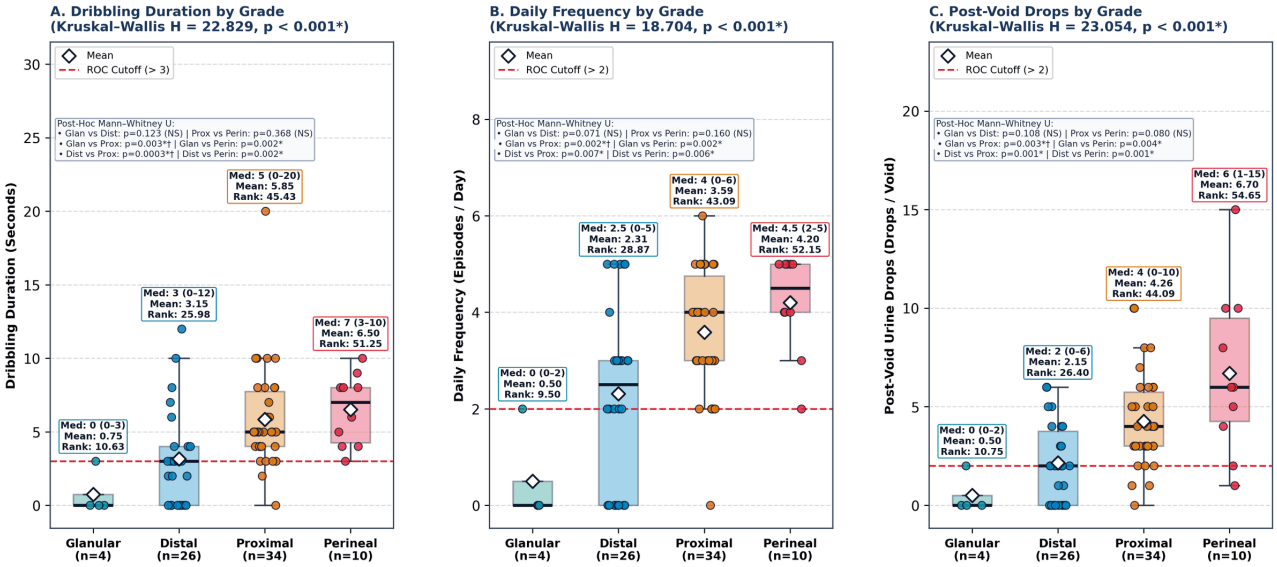


**Figure 3.** Nonparametric and parametric comparisons of preoperative terminal dribbling characteristics across the four hypospadias grades (N = 74): (A) dribbling duration in seconds (Kruskal–Wallis H = 22.829, df = 3, p < 0.001, $\varepsilon^2 = 0.313$; medians: glanular 0 s, distal 3 s, proximal 5 s, perineal 7 s); (B) daily dribbling frequency in episodes/day (Kruskal–Wallis H = 18.704, df = 3, p < 0.001, $\varepsilon^2 = 0.256$; medians: glanular 0/day, distal 2.5/day, proximal 4/day, perineal 4.5/day); and (C) post-void urine drops per micturition (Kruskal–Wallis H = 23.054, df = 3, p < 0.001, $\varepsilon^2 = 0.316$; medians: glanular 0 drops, distal 2 drops, proximal 4 drops, perineal 6 drops), annotated with post-hoc Mann–Whitney U pairwise significance showing homogeneity within anterior (glanular vs. distal: p = 0.123, 0.071, 0.108) and posterior (proximal vs. perineal: p = 0.368, 0.160, 0.080) pairs but highly significant divergence across all anterior-to-posterior comparisons (all p ≤ 0.007). †Asymptotic p value computed from the printed Z statistic.

Similarly, daily terminal dribbling frequency rose monotonically from a median of 0 episodes/day (0–2/day; mean ± SD: 0.50 ± 1.00/day; IQR: 0.00–0.50/day; mean rank: 9.50) in glanular cases to 2.5 episodes/day (0–5/day; mean ± SD: 2.31 ± 1.85/day; IQR: 0.00–3.00/day; mean rank: 28.87) in distal cases, 4 episodes/day (0–6/day; mean ± SD: 3.59 ± 1.26/day; IQR: 3.00–4.75/day; mean rank: 43.09) in proximal cases, and 4.5 episodes/day (2–5/day; mean ± SD: 4.20 ± 1.03/day; IQR: 4.00–5.00/day; mean rank: 52.15) in perineal cases. This four-group gradient was significant on the Kruskal–Wallis test (H = 18.704, df = 3, p < 0.001; $\varepsilon^2 = 0.256$; Spearman ρ = 0.490, p < 0.001) (Table 3 and Figure 3B). For post-void urine drops per micturition, the median count escalated threefold from 0 drops (0–2 drops; mean ± SD: 0.50 ± 1.00 drops; IQR: 0.00–0.50 drops; mean rank: 10.75) in glanular hypospadias and 2 drops (0–6 drops; mean ± SD: 2.15 ± 1.97 drops; IQR: 0.00–3.75 drops; mean rank: 26.40) in distal hypospadias to 4 drops (0–10 drops; mean ± SD: 4.26 ± 2.38 drops; IQR: 3.00–5.75 drops; mean rank: 44.09) in proximal hypospadias and 6 drops (1–15 drops; mean ± SD: 6.70 ± 4.19 drops; IQR: 4.25–9.50 drops; mean rank: 54.65) in perineal hypospadias (Kruskal–Wallis H = 23.054, df = 3, p < 0.001; $\varepsilon^2 = 0.316$; Spearman ρ = 0.556, p < 0.001) (Table 3 and Figure 3C). Complete absence of terminal dribbling across all three metrics (0 seconds, 0 episodes/day, 0 drops) was observed in 75.0% (3/4) of glanular patients and 30.8% (8/26) of distal patients, compared with only 2.9% (1/34) of proximal patients and 0.0% (0/10) of perineal patients.

**Table 3.** Comparison of Preoperative Terminal Dribbling Characteristics Across Four-Tier and Dichotomized Hypospadias Grades Using Kruskal–Wallis H and Post-Hoc Pairwise Mann–Whitney U Tests (N = 74).

| Hypospadias Grade / Pairwise Comparison | Dribbling Duration (Seconds) Med (Min–Max) \| Mean ± SD [Mean Rank / Test Stat] | Dribbling Frequency (Episodes/Day) Med (Min–Max) \| Mean ± SD [Mean Rank / Test Stat] | Post-Void Urine Drops (Drops/Void) Med (Min–Max) \| Mean ± SD [Mean Rank / Test Stat] | Overall / Pairwise Statistical Significance & Effect Size |
|---|---|---|---|---|
| Glanular Hypospadias (n = 4; 5.4%) | 0 (0–3) s \| 0.75 ± 1.50 s [IQR: 0.00–0.75; Mean Rank: 10.63] | 0 (0–2) /d \| 0.50 ± 1.00 /d [IQR: 0.00–0.50; Mean Rank: 9.50] | 0 (0–2) drops \| 0.50 ± 1.00 [IQR: 0.00–0.50; Mean Rank: 10.75] | Asymptomatic (0/0/0): 3/4 (75.0%) patients |
| Distal Hypospadias (n = 26; 35.1%) | 3 (0–12) s \| 3.15 ± 3.21 s [IQR: 0.00–4.00; Mean Rank: 25.98] | 2.5 (0–5) /d \| 2.31 ± 1.85 /d [IQR: 0.00–3.00; Mean Rank: 28.87] | 2 (0–6) drops \| 2.15 ± 1.97 [IQR: 0.00–3.75; Mean Rank: 26.40] | Asymptomatic (0/0/0): 8/26 (30.8%) patients |
| Proximal Hypospadias (n = 34; 45.9%) | 5 (0–20) s \| 5.85 ± 3.47 s [IQR: 4.00–7.75; Mean Rank: 45.43] | 4 (0–6) /d \| 3.59 ± 1.26 /d [IQR: 3.00–4.75; Mean Rank: 43.09] | 4 (0–10) drops \| 4.26 ± 2.38 [IQR: 3.00–5.75; Mean Rank: 44.09] | Asymptomatic (0/0/0): 1/34 (2.9%) patients |
| Perineal Hypospadias (n = 10; 13.5%) | 7 (3–10) s \| 6.50 ± 2.42 s [IQR: 4.25–8.00; Mean Rank: 51.25] | 4.5 (2–5) /d \| 4.20 ± 1.03 /d [IQR: 4.00–5.00; Mean Rank: 52.15] | 6 (1–15) drops \| 6.70 ± 4.19 [IQR: 4.25–9.50; Mean Rank: 54.65] | Asymptomatic (0/0/0): 0/10 (0.0%; 100% Symptomatic) |

| Hypospadias Grade / Pairwise Comparison | Dribbling Duration (Seconds) Med (Min–Max) \| Mean ± SD [Mean Rank / Test Stat] | Dribbling Frequency (Episodes/Day) Med (Min–Max) \| Mean ± SD [Mean Rank / Test Stat] | Post-Void Urine Drops (Drops/Void) Med (Min–Max) \| Mean ± SD [Mean Rank / Test Stat] | Overall / Pairwise Statistical Significance & Effect Size |
|---|---|---|---|---|
| Omnibus Kruskal–Wallis H (df = 3; N = 74) | H = 22.829 \| p < 0.001* ($\varepsilon^2$ = 0.313) Spearman ρ = 0.544 (p < 0.001) | H = 18.704 \| p < 0.001* ($\varepsilon^2$ = 0.256) Spearman ρ = 0.490 (p < 0.001) | H = 23.054 \| p < 0.001* ($\varepsilon^2$ = 0.316) Spearman ρ = 0.556 (p < 0.001) | Highly significant monotonic increase across all 3 domains (All p < 0.001*) |
| Dichotomized Summary: Glanular–Distal (n = 30) vs. Proximal–Perineal (n = 44) | GD: 3.0 (0–12) \| 2.83 ± 3.13 s PP: 5.0 (0–20) \| 6.00 ± 3.25 s Mann–Whitney U = 253.0 (p < 0.001*) | GD: 2.0 (0–5) \| 2.07 ± 1.86 /d PP: 4.0 (0–6) \| 3.73 ± 1.23 /d Mann–Whitney U = 323.5 (p < 0.001*) | GD: 2.0 (0–6) \| 1.93 ± 1.95 PP: 4.0 (0–15) \| 4.82 ± 3.01 Mann–Whitney U = 264.5 (p < 0.001*) | Rank-Biserial $\|r_{rb}\|$: Dur = 0.617 \| Freq = 0.510 Drops = 0.599 (All p < 0.001*) |
| Post-Hoc Pair 1: Glanular (4) vs. Distal (26) | U = 26.500 \| W = 36.500 Z = −1.613 \| p = 0.123 | U = 22.500 \| W = 32.500 Z = −1.870 \| p = 0.071 | U = 25.500 \| W = 35.500 Z = −1.676 \| p = 0.108 | Not Statistically Significant (All p > 0.05; Homogeneous Anterior Spectrum) |
| Post-Hoc Pair 2: Glanular (4) vs. Proximal (34) | U = 5.500 \| W = 15.500 Z = −3.015 \| p = 0.003*† | U = 5.000 \| W = 15.000 Z = −3.067 \| p = 0.002*† | U = 6.000 \| W = 16.000 Z = −2.987 \| p = 0.003*† | Statistically Significant Difference Across All 3 Parameters (p < 0.01*) |
| Post-Hoc Pair 3: Glanular (4) vs. Perineal (10) | U = 0.500 \| W = 10.500 Z = −2.789 \| p = 0.002* | U = 0.500 \| W = 10.500 Z = −2.850 \| p = 0.002* | U = 1.500 \| W = 11.500 Z = −2.637 \| p = 0.004* | Statistically Significant Difference Across All 3 Parameters (p < 0.01*) |
| Post-Hoc Pair 4: Distal (26) vs. Proximal (34) | U = 202.000 \| W = 553.000 Z = −3.615 \| p = 0.0003*† | U = 264.000 \| W = 615.000 Z = −2.718 \| p = 0.007* | U = 217.000 \| W = 568.000 Z = −3.391 \| p = 0.001* | Statistically Significant Difference Across All 3 Parameters (p < 0.01*) |
| Post-Hoc Pair 5: Distal (26) vs. Perineal (10) | U = 45.000 \| W = 396.000 Z = −3.042 \| p = 0.002* | U = 54.000 \| W = 405.000 Z = −2.752 \| p = 0.006* | U = 40.000 \| W = 391.000 Z = −3.220 \| p = 0.001* | Statistically Significant Difference Across All 3 Parameters (p < 0.01*) |
| Post-Hoc Pair 6: Proximal (34) vs. Perineal (10) | U = 137.000 \| W = 732.000 Z = −0.938 \| p = 0.368 | U = 119.000 \| W = 714.000 Z = −1.476 \| p = 0.160 | U = 107.000 \| W = 702.000 Z = −1.782 \| p = 0.080 | Not Statistically Significant (All p > 0.05; Homogeneous Posterior Spectrum) |

*Abbreviations: df, degrees of freedom; GD, glanular–distal group; IQR, interquartile range (25th–75th percentile); Med, median; PP, proximal–perineal group; SD, standard deviation; U, Mann–Whitney U statistic; W, Wilcoxon rank-sum statistic; $\varepsilon^2$, epsilon-squared effect size; ρ, Spearman's rank correlation coefficient. *p < 0.05. †Asymptotic p value computed from the printed Z statistic (the printed exact p < 0.001 is not possible for 4 versus 34 patients).*

Post-hoc pairwise Mann–Whitney U tests across all six anatomical grade pairs showed a clear two-group pattern (Table 3 and Figure 3). Within the anterior spectrum, comparing glanular (n = 4) versus distal (n = 26) hypospadias yielded no statistically significant difference in dribbling duration (U = 26.500, W = 36.500, Z = −1.613, p = 0.123), daily frequency (U = 22.500, W = 32.500, Z = −1.870, p = 0.071), or post-void drops (U = 25.500, W = 35.500, Z = −1.676, p = 0.108). Likewise, within the posterior spectrum, comparing proximal (n = 34) versus perineal (n = 10) hypospadias revealed no statistically significant pairwise difference in duration (U = 137.000, W = 732.000, Z = −0.938, p = 0.368), daily frequency (U = 119.000, W = 714.000, Z = −1.476, p = 0.160), or post-void drops (U = 107.000, W = 702.000, Z = −1.782, p = 0.080). In contrast, all four pairwise comparisons crossing the anterior–posterior anatomical boundary were statistically significant across every parameter (asymptotic p values computed from Z are given for glanular versus proximal and for distal versus proximal duration): glanular versus proximal (duration: U = 5.500, Z = −3.015, p = 0.003; frequency: U = 5.000, Z = −3.067, p = 0.002; drops: U = 6.000, Z = −2.987, p = 0.003), glanular versus perineal (duration: U = 0.500, Z = −2.789, p = 0.002; frequency: U = 0.500, Z = −2.850, p = 0.002; drops: U = 1.500, Z = −2.637, p = 0.004), distal versus proximal (duration: U = 202.000, Z = −3.615, p = 0.0003; frequency: U = 264.000, Z = −2.718, p = 0.007; drops: U = 217.000, Z = −3.391, p = 0.001), and distal versus perineal (duration: U = 45.000, Z = −3.042, p = 0.002; frequency: U = 54.000, Z = −2.752, p = 0.006; drops: U = 40.000, Z = −3.220, p = 0.001). The similarity within the anterior pair and within the posterior pair, together with the divergence between them, supported dichotomizing the cohort into glanular–distal (n = 30) and proximal–perineal (n = 44) groups (duration: 2.83 ± 3.13 s vs. 6.00 ± 3.25 s, U = 253.0, p < 0.001, $|r_{rb}|$ = 0.617; frequency: 2.07 ± 1.86/day vs. 3.73 ± 1.23/day, U = 323.5, p < 0.001, $|r_{rb}|$ = 0.510; drops: 1.93 ± 1.95 vs. 4.82 ± 3.01, U = 264.5, p < 0.001, $|r_{rb}|$ = 0.599) (Table 3).

Table 3 gives the parametric and nonparametric profile of each grade, which shows the size of the anatomical gradient. For terminal dribbling duration, the 95% CI of the mean was 1.86 to 4.45 seconds in distal (mean 3.15 ± 3.21 s), 4.64 to 7.06 seconds in proximal (mean 5.85 ± 3.47 s), and 4.77 to 8.23 seconds in perineal (mean 6.50 ± 2.42 s) hypospadias. For daily dribbling frequency, the corresponding intervals were 1.56 to 3.05 episodes/day in distal (mean 2.31 ± 1.85/day), 3.15 to 4.03 episodes/day in proximal (mean 3.59 ± 1.26/day), and 3.46 to 4.94 episodes/day in perineal (mean 4.20 ± 1.03/day) hypospadias. For post-void urine drops, they were 1.36 to 2.95 drops in distal (mean 2.15 ± 1.97 drops), 3.43 to 5.10 drops in proximal (mean 4.26 ± 2.38 drops), and 3.70 to 9.70 drops in perineal (mean 6.70 ± 4.19 drops) hypospadias. The glanular group (n = 4) is described by its median and range only (Table 3), because a confidence interval of the mean is not meaningful for four non-negative counts (its t-based limits would be negative). Across all six pairwise Mann–Whitney U comparisons (Table 3), whether evaluated using exact small-sample permutation probabilities or asymptotic normal-approximation Z probabilities, the statistical conclusion was identical: anterior grades (glanular and distal) shared a lower-rank distribution, posterior grades (proximal and perineal) shared a higher-rank distribution, and the boundary between distal and proximal hypospadias marked the largest step.

### *ROC analysis*

To describe exploratory thresholds of terminal dribbling parameters that best separate posterior (proximal–perineal, n = 44; 59.46%) from anterior (glanular–distal, n = 30; 40.54%) hypospadias, nonparametric ROC curve analysis was performed (Table 4 and Figure 4). All three quantitative parameters demonstrated statistically significant discrimination above chance (all p < 0.001). Terminal dribbling duration achieved the highest discriminative performance, with an AUC of 0.808 ± 0.0574 (binomial exact 95% CI: 0.700–0.891; z-statistic = 5.373; p < 0.001). Maximization of Youden's Index identified an optimal criterion of >3 seconds (≤3 s vs. >3 s; Youden's J = 0.5742), which yielded a sensitivity of 84.09% (37/44 proximal–perineal cases correctly classified), a specificity of 73.33% (22/30 glanular–distal cases correctly classified), a positive predictive value

(PPV) of 82.22% (37/45), a negative predictive value (NPV) of 75.86% (22/29), an overall diagnostic accuracy of 79.73% (59/74), a positive likelihood ratio (LR+) of 3.153, and a negative likelihood ratio (LR−) of 0.217 (Table 4 and Figure 4).

**Table 4.** Receiver Operating Characteristic (ROC) Curve Analysis and Diagnostic Threshold Optimization of Terminal Dribbling Parameters for Discriminating Proximal–Perineal (n = 44; 59.46%) from Glanular–Distal (n = 30; 40.54%) Hypospadias (N = 74).

| Terminal Dribbling Diagnostic Parameter | AUC ± SE[a] (95% CI[b]) [z-Stat; p-value] | Optimal Cutoff & Youden's Index J (J = Se + Sp − 1) | Sensitivity (%) [TP / Positive n] & Specificity (%) [TN / Negative n] | PPV (%) [TP / Test+] NPV (%) [TN / Test−] & Overall Accuracy (%) | Likelihood Ratios (LR+ and LR−) & Discriminative Rank |
|---|---|---|---|---|---|
| Dribbling Duration (Seconds after Main Stream Cessation) | AUC = 0.808 ± 0.0574 (95% CI: 0.700–0.891) [z = 5.373; p < 0.001*] | Cutoff: >3 Seconds (≤3 s vs. >3 s) Youden's J = 0.5742 | Sensitivity: 84.09% [37 / 44 Proximal–Perineal] Specificity: 73.33% [22 / 30 Glanular–Distal] | PPV: 82.22% (37/45) NPV: 75.86% (22/29) Accuracy: 79.73% (59/74) | LR+ = 3.153 LR− = 0.217 Rank #1 (Highest AUC & J) |
| Post-Void Urine Drops (Drops Counted on Video Recording) | AUC = 0.800 ± 0.0523 (95% CI: 0.690–0.884) [z = 5.734; p < 0.001*] | Cutoff: >2 Drops (≤2 vs. >2 drops) Youden's J = 0.5182 | Sensitivity: 81.82% [36 / 44 Proximal–Perineal] Specificity: 70.00% [21 / 30 Glanular–Distal] | PPV: 80.00% (36/45) NPV: 72.41% (21/29) Accuracy: 77.03% (57/74) | LR+ = 2.727 LR− = 0.260 Rank #2 (Good Discrimination) |
| Dribbling Frequency (Daily Episodes in Past 1 Week) | AUC = 0.755 ± 0.0603 (95% CI: 0.641–0.848) [z = 4.228; p < 0.001*] | Cutoff: >2 Episodes/Day (≤2 vs. >2 /day) Youden's J = 0.4076 | Sensitivity: 84.09% [37 / 44 Proximal–Perineal] Specificity: 56.67% [17 / 30 Glanular–Distal] | PPV: 74.00% (37/50) NPV: 70.83% (17/24) Accuracy: 72.97% (54/74) | LR+ = 1.941 LR− = 0.281 Rank #3 (Fair-to-Good AUC) |

*Abbreviations: AUC, area under the receiver operating characteristic curve; CI, confidence interval; J, Youden's index; LR+, positive likelihood ratio; LR−, negative likelihood ratio; NPV, negative predictive value; PPV, positive predictive value; SE, standard error; Se, sensitivity; Sp, specificity; TN, true negative; TP, true positive. [a]DeLong et al.[33] standard error method; [b]Binomial exact 95% confidence interval. *Statistically significant versus null AUC = 0.500 (p < 0.001).*

Post-void urine drop count ranked second in discriminative accuracy, achieving an AUC of 0.800 ± 0.0523 (95% CI: 0.690–0.884; z-statistic = 5.734; p < 0.001). The Youden-optimal threshold was >2 drops per void (≤2 vs. >2 drops; Youden's J = 0.5182), providing a sensitivity of 81.82% (36/44), a specificity of 70.00% (21/30), a PPV of 80.00% (36/45), an NPV of 72.41% (21/29), an overall diagnostic accuracy of 77.03% (57/74), an LR+ of 2.727, and an LR− of 0.260. Daily terminal dribbling frequency demonstrated fair-to-good discriminative ability with an AUC of 0.755 ± 0.0603 (95% CI: 0.641–0.848; z-statistic = 4.228; p < 0.001). At its optimal cutoff of >2 episodes/day (≤2 vs. >2 episodes/day; Youden's J = 0.4076), daily frequency achieved a sensitivity of 84.09% (37/44), a specificity of 56.67% (17/30), a PPV of 74.00% (37/50), an NPV of 70.83% (17/24), an overall accuracy of 72.97% (54/74), an LR+ of 1.941, and an LR− of 0.281 (Table 4 and Figure 4).

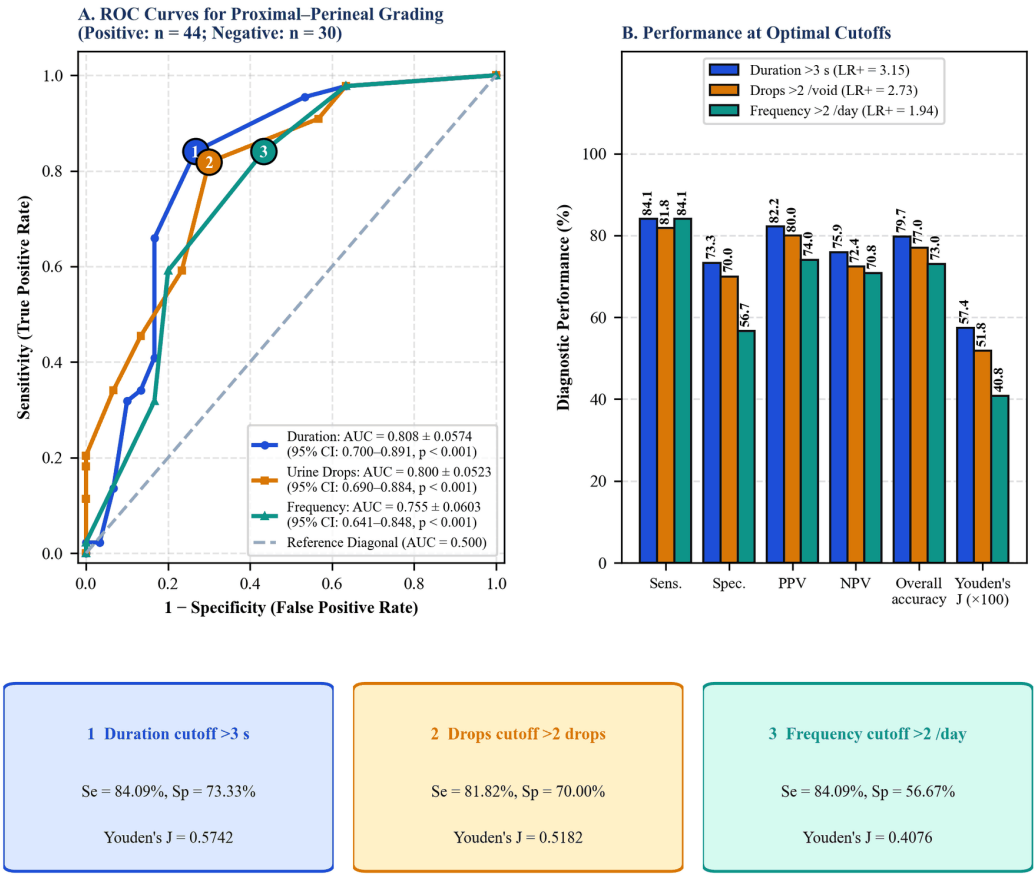


**Figure 4.** Receiver operating characteristic (ROC) curve analysis and Youden threshold optimization for discriminating proximal–perineal (n = 44; 59.46%) from glanular–distal (n = 30; 40.54%) preoperative hypospadias (N = 74): (A) empirical ROC curves demonstrating significant discriminative accuracy for dribbling duration (AUC = 0.808 ± 0.0574, 95% CI: 0.700–0.891, z = 5.373, p < 0.001; optimal cutoff >3 s, Youden's J = 0.5742), post-void urine drops (AUC = 0.800 ± 0.0523, 95% CI: 0.690–0.884, z = 5.734, p < 0.001; optimal cutoff >2 drops, J = 0.5182), and daily frequency (AUC = 0.755 ± 0.0603, 95% CI: 0.641–0.848, z = 4.228, p < 0.001; optimal cutoff >2 episodes/day, J = 0.4076); and (B) comparative diagnostic performance profile of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy at each optimal cutoff.

A comparative inspection of the ROC coordinate trajectories across the three parameters revealed why duration (>3 s) and post-void drops (>2 drops) outperformed daily frequency (>2/day) in diagnostic specificity (73.33% and 70.00% vs.

56.67%). Whereas 37 of 44 proximal–perineal patients (84.09%) exceeded both the >3-second duration cutoff and the >2-episode/day frequency cutoff (yielding identical sensitivities of 84.09%), only 8 of 30 glanular–distal patients (26.67% false-positive rate) exhibited a video-timed duration >3 seconds and 9 of 30 (30.00% false-positive rate) shed >2 drops, whereas 13 of 30 glanular–distal patients (43.33% false-positive rate) reported >2 daily dribbling episodes over the preceding week. Video-measured duration >3 seconds therefore had the highest positive likelihood ratio (LR+ = 3.153) and the lowest negative likelihood ratio (LR− = 0.217): dribbling longer than 3 seconds was about three times as frequent among children with posterior defects as among those with anterior defects.

### *Dichotomized dribbling parameters, contingency analysis and logistic regression*

Applying the ROC-derived thresholds, categorical contingency analyses were conducted across both the four-tier classification (4 × 2 tables) and the dichotomized anatomical classification (2 × 2 tables), supplemented by multivariable logistic regression adjusting for patient age and parental education (Table 5 and Figure 5). For terminal dribbling duration, 29 patients (39.2%) had a duration of ≤3 seconds and 45 patients (60.8%) had a duration of >3 seconds. Across the four Hadidi grades (4 × 2 table), duration ≤3 seconds comprised 4 glanular (13.8% of row), 18 distal (62.1%), 6 proximal (20.7%), and 1 perineal (3.4%) patient, whereas duration >3 seconds comprised 0 glanular (0.0%), 8 distal (17.8%), 28 proximal (62.2%), and 9 perineal (20.0%) patients (Pearson $\chi^2 = 26.249$, df = 3, $p < 0.001$; likelihood ratio $G^2 = 28.813$; linear-by-linear association = 22.767, $p < 0.001$). In the 2 × 2 contingency analysis, 37 of 44 proximal–perineal patients (84.1% within grade; 82.2% of the >3 s row) exhibited prolonged dribbling >3 seconds compared with only 8 of 30 glanular–distal patients (26.7% within grade; 17.8% of the >3 s row), while 22 of 30 glanular–distal patients (73.3% within grade; 75.9% of the ≤3 s row) had dribbling ≤3 seconds compared with 7 of 44 proximal–perineal patients (15.9% within grade; 24.1% of the ≤3 s row) (Pearson $\chi^2 = 24.682$, df = 1, $p < 0.001$; Yates' continuity correction = 22.331, $p < 0.001$; $G^2 = 25.746$; two-sided Fisher's exact $p < 0.001$; $\varphi = 0.578$; minimum expected cell count = 11.76). Epidemiologically, proximal–perineal hypospadias was associated with a 14.536-fold higher crude odds of prolonged dribbling >3 seconds (OR = 14.536, 95% CI: 4.63–45.61; RR = 3.153, 95% CI: 1.718–5.787; RD = +57.4%), which strengthened to an adjusted odds ratio of aOR = 19.607 (95% CI: 5.29–72.60; $p < 0.001$) after controlling for patient age and parental education (Table 5 and Figure 5).

**Table 5.** Contingency Analysis (4 × 2 and 2 × 2), Chi-Square / Fisher's Exact Tests, and Unadjusted Versus Multivariable-Adjusted Risk Estimates for ROC-Dichotomized Terminal Dribbling Parameters Across Hypospadias Grades (N = 74).

| Terminal Dribbling Cutoff Category | 4-Tier Hypospadias Grade Distribution Glanular (4) \| Distal (26) \| Proximal (34) \| Perineal (10) [Count (% Within Row Cutoff)] | Dichotomized Grade Distribution Glanular–Distal (n = 30) vs. Proximal–Perineal (n = 44) [% Row \| % Within Grade] | Total n (%) | 4 × 2 & 2 × 2 Chi-Square, Yates, Likelihood Ratio, Fisher's Exact & Phi (φ) | Crude OR, RR, RD & Multivariable Adjusted OR (aOR)[a] (95% Confidence Interval) |
|---|---|---|---|---|---|
| Duration: ≤3 Seconds (Below/At ROC Cutoff) | Glanular: 4 (13.8%) \| Distal: 18 (62.1%) Proximal: 6 (20.7%) \| Perineal: 1 (3.4%) | GD: 22 (75.9% row \| 73.3% of GD) PP: 7 (24.1% row \| 15.9% of PP) | 29 (39.2%) | 4×2 $\chi^2 = 26.249$ ($p < 0.001$*) 4×2 $G^2 = 28.813$ \| LLA = 22.767 2×2 $\chi^2 = 24.682$ ($p < 0.001$*) Yates = 22.331 \| $G^2 = 25.746$ Fisher's Exact $p < 0.001$* Phi $\varphi = 0.578$ | 1.000 (Reference) Cohort Ratio (GD vs PP for ≤3 s): 4.610 (2.260–9.402) |
| Duration: >3 Seconds (Above ROC Cutoff) | Glanular: 0 (0.0%) \| Distal: 8 (17.8%) Proximal: 28 (62.2%) \| Perineal: 9 (20.0%) | GD: 8 (17.8% row \| 26.7% of GD) PP: 37 (82.2% row \| 84.1% of PP) | 45 (60.8%) | Min Expected Count (2×2) = 11.76 (0 cells < 5; 100% Valid N = 74) | Crude OR: 14.536 (95% CI: 4.63–45.61) RR (PP vs GD): 3.153 (1.718–5.787) Risk Difference (RD): +57.4% aOR: 19.607 (5.29–72.60; $p < 0.001$*) |
| Frequency: ≤2 /Day (Below/At ROC Cutoff) | Glanular: 4 (16.7%) \| Distal: 13 (54.2%) Proximal: 6 (25.0%) \| Perineal: 1 (4.2%) | GD: 17 (70.8% row \| 56.7% of GD) PP: 7 (29.2% row \| 15.9% of PP) | 24 (32.4%) | 4×2 $\chi^2 = 17.683$ ($p = 0.001$*) 4×2 $G^2 = 19.019$ \| LLA = 15.194 2×2 $\chi^2 = 13.522$ ($p = 0.0002$*) Yates = 11.726 ($p = 0.001$) \| $G^2 = 13.641$ Fisher's Exact $p = 0.0004$* Phi $\varphi = 0.427$ | 1.000 (Reference) Cohort Ratio (GD vs PP for ≤2 /d): 3.562 (1.686–7.525) |
| Frequency: >2 /Day (Above ROC Cutoff) | Glanular: 0 (0.0%) \| Distal: 13 (26.0%) Proximal: 28 (56.0%) \| Perineal: 9 (18.0%) | GD: 13 (26.0% row \| 43.3% of GD) PP: 37 (74.0% row \| 84.1% of PP) | 50 (67.6%) | Min Expected Count (2×2) = 9.73 (0 cells < 5; 100% Valid N = 74) | Crude OR: 6.912 (95% CI: 2.34–20.43) RR (PP vs GD): 1.941 (1.264–2.980) Risk Difference (RD): +40.8% aOR: 6.749 (2.18–20.92; $p = 0.001$*) |
| Drops: ≤2 Drops/Void (Below/At ROC Cutoff) | Glanular: 4 (13.8%) \| Distal: 17 (58.6%) Proximal: 6 (20.7%) \| Perineal: 2 (6.9%) | GD: 21 (72.4% row \| 70.0% of GD) PP: 8 (27.6% row \| 18.2% of PP) | 29 (39.2%) | 4×2 $\chi^2 = 21.859$ ($p < 0.001$*) 4×2 $G^2 = 23.861$ \| LLA = 17.302 2×2 $\chi^2 = 20.098$ ($p < 0.001$*) Yates = 17.983 \| $G^2 = 20.723$ Fisher's Exact $p < 0.001$* Phi $\varphi = 0.521$ | 1.000 (Reference) Cohort Ratio (GD vs PP for ≤2 drops): 3.850 (1.972–7.517) |
| Drops: >2 Drops/Void (Above ROC Cutoff) | Glanular: 0 (0.0%) \| Distal: 9 (20.0%) Proximal: 28 (62.2%) \| Perineal: 8 (17.8%) | GD: 9 (20.0% row \| 30.0% of GD) PP: 36 (80.0% row \| 81.8% of PP) | 45 (60.8%) | Min Expected Count (2×2) = 11.76 (0 cells < 5; 100% Valid N = 74) | Crude OR: 10.500 (95% CI: 3.52–31.35) RR (PP vs GD): 2.727 (1.551–4.794) Risk Difference (RD): +51.8% aOR: 13.339 (3.91–45.48; $p < 0.001$*) |

*Abbreviations: aOR, multivariable adjusted odds ratio; CI, confidence interval; $G^2$, likelihood ratio chi-square; GD, glanular–distal hypospadias (n = 30); LLA, linear-by-linear association; OR, odds ratio; PP, proximal–perineal hypospadias (n = 44); RD, absolute risk difference; ROC, receiver operating characteristic; RR, relative risk; $\chi^2$, Pearson chi-square; φ, phi coefficient. [a]Adjusted in multivariable logistic regression for patient age (years) and parental educational attainment. *p < 0.01.*

For daily terminal dribbling frequency, 24 patients (32.4%) experienced ≤2 episodes/day and 50 patients (67.6%) experienced >2 episodes/day. In the 4 × 2 distribution, frequency ≤2/day included 4 glanular (16.7% of row), 13 distal (54.2%), 6 proximal (25.0%), and 1 perineal (4.2%) patient, whereas frequency >2/day included 0 glanular (0.0%), 13 distal (26.0%), 28 proximal (56.0%), and 9 perineal (18.0%) patients (Pearson $\chi^2$ = 17.683, df = 3, p = 0.001; $G^2$ = 19.019; linear-by-linear association = 15.194, p < 0.001). In the 2 × 2 comparison, 37 of 44 proximal–perineal patients (84.1% within grade; 74.0% of the >2/day row) had >2 episodes/day versus 13 of 30 glanular–distal patients (43.3% within grade; 26.0% of the >2/day row), whereas 17 of 30 glanular–distal patients (56.7% within grade; 70.8% of the ≤2/day row) had ≤2 episodes/day versus 7 of 44 proximal–perineal patients (15.9% within grade; 29.2% of the ≤2/day row) (Pearson $\chi^2$ = 13.522, df = 1, p = 0.0002; Yates' correction = 11.726, p = 0.001; $G^2$ = 13.641; Fisher's exact p = 0.0004; φ = 0.427; minimum expected count = 9.73). Patients with proximal–perineal hypospadias had nearly sevenfold higher odds of frequent dribbling >2 episodes/day both in unadjusted analysis (OR = 6.912, 95% CI: 2.34–20.43; RR = 1.941, 95% CI: 1.264–2.980; RD = +40.8%) and after multivariable adjustment (aOR = 6.749, 95% CI: 2.18–20.92; p = 0.001) (Table 5 and Figure 5).

For post-void urine drops, 29 patients (39.2%) had ≤2 drops/void and 45 patients (60.8%) had >2 drops/void. In the 4 × 2 contingency table, ≤2 drops comprised 4 glanular (13.8% of row), 17 distal (58.6%), 6 proximal (20.7%), and 2 perineal (6.9%) patients, while >2 drops comprised 0 glanular (0.0%), 9 distal (20.0%), 28 proximal (62.2%), and 8 perineal (17.8%) patients (Pearson $\chi^2$ = 21.859, df = 3, p < 0.001; $G^2$ = 23.861; linear-by-linear association = 17.302, p < 0.001). In the 2 × 2 table, 36 of 44 proximal–perineal patients (81.8% within grade; 80.0% of the >2 drops row) shed >2 drops per void compared with 9 of 30 glanular–distal patients (30.0% within grade; 20.0% of the >2 drops row), whereas 21 of 30 glanular–distal patients (70.0% within grade; 72.4% of the ≤2 drops row) shed ≤2 drops compared with 8 of 44 proximal–perineal patients (18.2% within grade; 27.6% of the ≤2 drops row) (Pearson $\chi^2$ = 20.098, df = 1, p < 0.001; Yates' correction = 17.983, p < 0.001; $G^2$ = 20.723; Fisher's exact p < 0.001; φ = 0.521; minimum expected count = 11.76). This corresponded to a crude odds ratio of OR = 10.500 (95% CI: 3.52–31.35; RR = 2.727, 95% CI: 1.551–4.794; RD = +51.8%) and a multivariable-adjusted odds ratio of aOR = 13.339 (95% CI: 3.91–45.48; p < 0.001) (Table 5 and Figure 5).

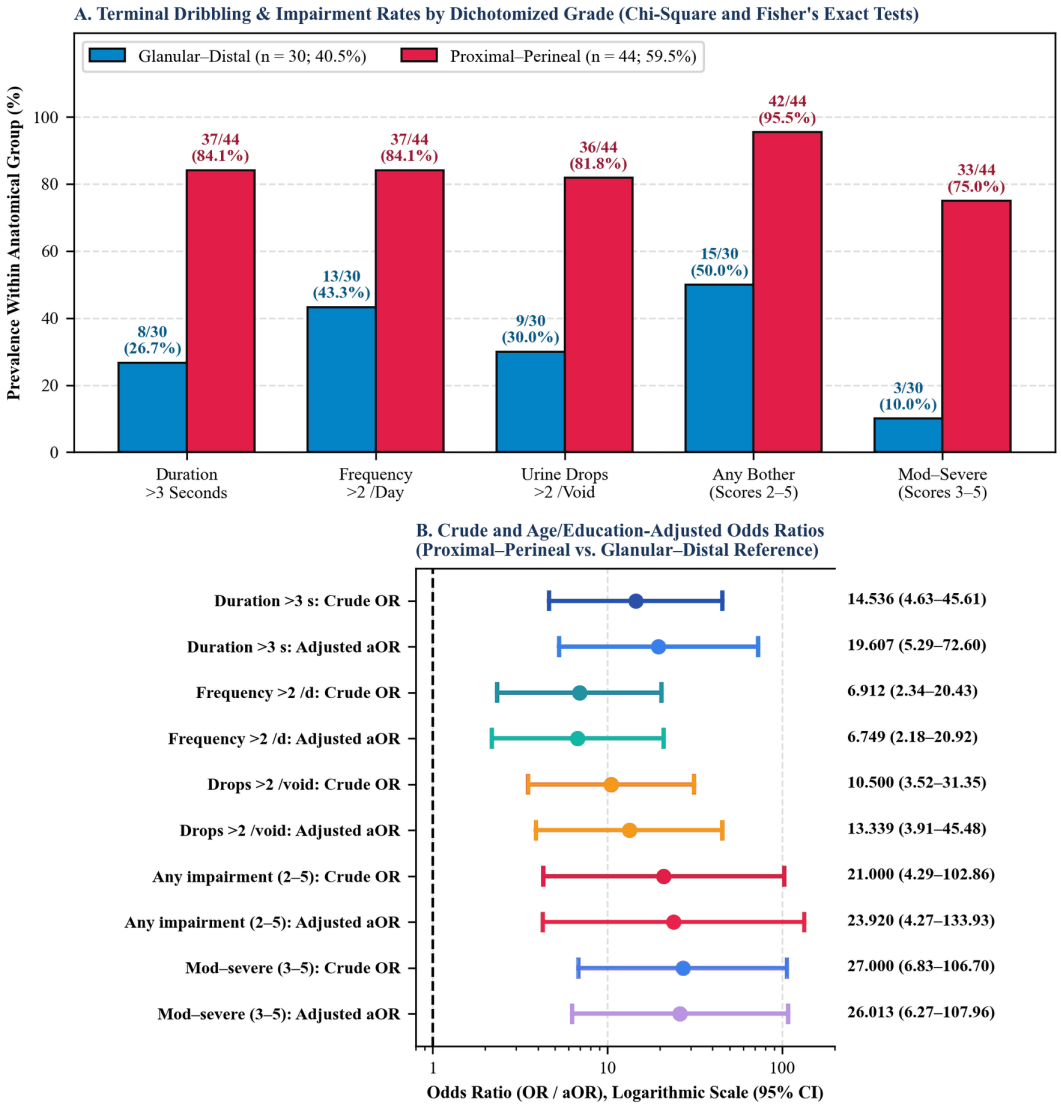


**Figure 5.** Categorical contingency distributions and unadjusted versus multivariable-adjusted odds ratio forest plot comparing proximal–perineal (n = 44) and glanular–distal (n = 30) hypospadias (N = 74): (A) proportion of patients exceeding ROC cutoffs and experiencing functional impairment within each anatomical group (duration >3 s: 84.1% [37/44] vs. 26.7% [8/30]; frequency >2/day: 84.1% [37/44] vs. 43.3% [13/30]; drops >2/void: 81.8% [36/44] vs. 30.0% [9/30]; any functional impairment [scores 2–5]: 95.5% [42/44] vs. 50.0% [15/30]; moderate-to-severe impairment [scores 3–5]: 75.0% [33/44] vs. 10.0% [3/30]; all

p < 0.001); and (B) logarithmic forest plot of crude odds ratios (OR = 14.536, 6.912, 10.500, 21.000, and 27.000), multivariable-adjusted odds ratios controlling for age and parental education (aOR = 19.607, 6.749, 13.339, 23.920, and 26.013). Relative risks are given in Tables 5 and 6.

### *Functional impairment*

Finally, the association between preoperative hypospadias grading and daily functional impairment was evaluated across both the full 5-level Likert scale (4 × 5 table) and the dichotomized impairment status (2 × 2 table) (Table 6 and Figure 5). Across the four anatomical grades, the distribution of functional bother shifted dramatically toward higher severity in posterior defects (4 × 5 Pearson $\chi^2 = 39.929$, df = 12, p < 0.001; $G^2 = 46.729$, p < 0.001; linear-by-linear association = 24.390, p < 0.001; Spearman ρ = 0.644, p < 0.001). Specifically, among glanular patients (n = 4), 3 (75.0%) were not bothered (Score 1) and 1 (25.0%) was slightly bothered (Score 2), with zero patients scoring 3–5. Among distal patients (n = 26), 12 (46.2%) were not bothered (Score 1), 11 (42.3%) were slightly bothered (Score 2), 2 (7.7%) were moderately bothered (Score 3), 0 (0.0%) were significantly bothered (Score 4), and 1 (3.8%) was extremely bothered (Score 5). Conversely, among proximal patients (n = 34), only 2 (5.9%) were not bothered, whereas 8 (23.5%) were slightly bothered, 17 (50.0%) were moderately bothered, 5 (14.7%) were significantly bothered, and 2 (5.9%) were extremely bothered. Among perineal patients (n = 10), 0 (0.0%) were unimpaired, 1 (10.0%) was slightly bothered, 6 (60.0%) were moderately bothered, and 3 (30.0%) were significantly bothered (Table 6).

When dichotomized into unimpaired (Score 1, n = 17) versus impaired (Scores 2–5, n = 57) in the primary 2 × 2 analysis, 42 of 44 proximal–perineal patients (95.5% within grade; 73.7% of all impaired cases) experienced functional impairment compared with 15 of 30 glanular–distal patients (50.0% within grade; 26.3% of all impaired cases), whereas 15 of 30 glanular–distal patients (50.0% within grade; 88.2% of all unimpaired cases) were unimpaired compared with only 2 of 44 proximal–perineal patients (4.5% within grade; 11.8% of all unimpaired cases) (Pearson $\chi^2 = 20.827$, df = 1, p < 0.001; Yates' correction = 18.338, p < 0.001; $G^2 = 21.904$; Fisher's exact p < 0.001; φ = 0.531; minimum expected count = 6.89). Proximal–perineal hypospadias was associated with a 21.000-fold higher crude odds of daily functional impairment (OR = 21.000, 95% CI: 4.29–102.86; RR = 1.909, 95% CI: 1.327–2.746; RD = +45.5%) and a multivariable-adjusted odds ratio of aOR = 23.920 (95% CI: 4.27–133.93; p < 0.001). Furthermore, in the prespecified sensitivity analysis comparing moderate-to-severe functional impairment (Scores 3–5, n = 36) against none-to-mild impairment (Scores 1–2, n = 38), 33 of 44 proximal–perineal patients (75.0%) experienced moderate-to-severe impairment compared with only 3 of 30 glanular–distal patients (10.0%) (Pearson $\chi^2 = 30.168$, p < 0.001; crude OR = 27.000, 95% CI: 6.83–106.70; multivariable aOR = 26.013, 95% CI: 6.27–107.96, p < 0.001) (Table 6 and Figure 5).

To verify the robustness of these contingency findings against demographic covariates, the multivariable binary logistic regression models adjusting simultaneously for continuous patient age (years) and parental educational attainment (5 ordinal levels) were examined in detail (Tables 5 and 6 and Figure 5B). Across all five binary endpoints, neither patient chronological age (all p > 0.20) nor parental educational level (all p > 0.25) acted as a statistically significant confounder, and adjustment left the anatomical grade effect largely unchanged or somewhat larger (three of five estimates increased), with wider confidence intervals: for duration >3 seconds, the crude OR of 14.536 (95% CI: 4.63–45.61) rose to an adjusted OR (aOR) of 19.607 (95% CI: 5.29–72.60, p < 0.001); for post-void drops >2 drops, the crude OR of 10.500 (3.52–31.35) rose to an aOR of 13.339 (3.91–45.48, p < 0.001); for daily frequency >2 episodes/day, the crude OR of 6.912 (2.34–20.43) remained stable at an aOR of 6.749 (2.18–20.92, p = 0.001); for any daily functional impairment (Scores 2–5 vs. Score 1), the crude OR of 21.000 (4.29–102.86) rose to an aOR of 23.920 (4.27–133.93, p < 0.001); and for moderate-to-severe functional impairment (Scores 3–5 vs. Scores 1–2), the crude OR of 27.000 (6.83–106.70) remained virtually unchanged at an aOR of 26.013 (6.27–107.96, p < 0.001).

**Table 6.** Association Between Preoperative Hypospadias Grading and Daily Functional Impairment Across the 5-Level Likert Scale (4 × 5) and Dichotomized Impairment Status (2 × 2) (N = 74).

| Hypospadias grade | Score 1 Not bothered n (% within grade) | Score 2 Slightly bothered n (%) | Score 3 Moderately bothered n (%) | Score 4 Significantly bothered n (%) | Score 5 Extremely bothered n (%) | Unimpaired (Score 1) vs. impaired (Scores 2–5) | Test statistics, crude OR, RR, RD and adjusted OR[a] |
|---|---|---|---|---|---|---|---|
| Glanular (n = 4; 5.4%) | 3 (75.0%) | 1 (25.0%) | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | Unimpaired: 3 (75.0%) Impaired: 1 (25.0%) | 4×5 Pearson $\chi^2 = 39.929$ (df = 12; p < 0.001*) 4×5 $G^2 = 46.729$ (p < 0.001*) Linear-by-Linear = 24.390 Spearman ρ = 0.644 (p < 0.001*) |
| Distal (n = 26; 35.1%) | 12 (46.2%) | 11 (42.3%) | 2 (7.7%) | 0 (0.0%) | 1 (3.8%) | Unimpaired: 12 (46.2%) Impaired: 14 (53.8%) | Moderate-to-Severe (Scores 3–5): Distal = 3/26 (11.5%) Glanular = 0/4 (0.0%) |
| Proximal (n = 34; 45.9%) | 2 (5.9%) | 8 (23.5%) | 17 (50.0%) | 5 (14.7%) | 2 (5.9%) | Unimpaired: 2 (5.9%) Impaired: 32 (94.1%) | Moderate-to-Severe (Scores 3–5): Proximal = 24/34 (70.6%) |
| Perineal (n = 10; 13.5%) | 0 (0.0%) | 1 (10.0%) | 6 (60.0%) | 3 (30.0%) | 0 (0.0%) | Unimpaired: 0 (0.0%) Impaired: 10 (100.0%) | Moderate-to-Severe (Scores 3–5): Perineal = 9/10 (90.0%) |
| Dichotomized: Glanular–Distal (n = 30; 40.5%) | 15 (50.0%) | 12 (40.0%) | 2 (6.7%) | 0 (0.0%) | 1 (3.3%) | Unimpaired: 15 (50.0%) Impaired: 15 (50.0%) | 1.000 (Reference Group) Unimpaired Cohort Ratio: 11.000 (2.711–44.631) |
| Dichotomized: Proximal–Perineal (n = 44; 59.5%) | 2 (4.5%) | 9 (20.5%) | 23 (52.3%) | 8 (18.2%) | 2 (4.5%) | Unimpaired: 2 (4.5%) Impaired: 42 (95.5%) | 2×2 $\chi^2 = 20.827$ (p < 0.001*) Yates = 18.338 \| $G^2 = 21.904$ Fisher's Exact p < 0.001* \| φ = 0.531 Crude OR: 21.000 (95% CI: 4.29–102.86) RR: 1.909 (1.327–2.746) \| RD: +45.5% aOR: 23.920 (4.27–133.93; p < 0.001*) |

| Hypospadias grade | Score 1 Not bothered n (% within grade) | Score 2 Slightly bothered n (%) | Score 3 Moderately bothered n (%) | Score 4 Significantly bothered n (%) | Score 5 Extremely bothered n (%) | Unimpaired (Score 1) vs. impaired (Scores 2–5) | Test statistics, crude OR, RR, RD and adjusted OR[a] |
|---|---|---|---|---|---|---|---|
| Total Cohort (N = 74; 100.0%) | 17 (23.0%) | 21 (28.4%) | 25 (33.8%) | 8 (10.8%) | 3 (4.1%) | Unimpaired: 17 (23.0%) Impaired: 57 (77.0%) | Sensitivity Analysis (Scores 3–5 vs 1–2): PP 75.0% (33/44) vs GD 10.0% (3/30) OR = 27.000 (6.83–106.70; p < 0.001*) aOR = 26.013 (6.27–107.96; p < 0.001*) |

*Abbreviations: aOR, multivariable adjusted odds ratio; df, degrees of freedom; $G^2$, likelihood ratio chi-square; GD, glanular–distal group; OR, odds ratio; PP, proximal–perineal group; RD, absolute risk difference; RR, relative risk; $\chi^2$, Pearson chi-square; φ, phi coefficient; ρ, Spearman's rank correlation. [a]Adjusted for patient age and parental education. Minimum expected count in the 2 × 2 table is 6.89 (0 cells < 5). *p < 0.001.*

## 4. Discussion

### *Sociodemographic and perinatal profile*

To our knowledge, this cross-sectional analytical study offers the first video-assisted quantitative description of preoperative terminal dribbling across anatomical grades of congenital hypospadias in Indonesia. The baseline demographic and perinatal profile of our 74-patient cohort needs context first. Several features stand out. Nearly two-thirds of those presenting for preoperative urological evaluation at Dr. Mohammad Hoesin Central General Hospital were older than five years (66.2%; 36.5% aged 6–10 years and 29.7% aged 11–18 years, with an overall mean age of 7.70 ± 4.59 years). Posterior phenotypes (proximal 45.9% and perineal 13.5%, totaling 59.5% proximal–perineal) outnumbered anterior phenotypes (distal 35.1% and glanular 5.4%, totaling 40.5% glanular–distal). Population-based birth registries in high-income healthcare systems look very different. In the nationwide Danish cohort of 9,189 boys reported by Leunbach et al., glanular and distal defects accounted for 91.5% of cases and proximal defects for only 8.5%.[5] Our data match an Indonesian tertiary hospital series from Malang, in which Henrizal et al. documented 52.0% proximal hypospadias among 250 consecutive patients.[6,11] Indriasari et al. in Bandung and Lestari et al. in Jember studied perinatal risk factors in Indonesian hospital cohorts.[10,27]

Two mechanisms may explain this tertiary epidemiological pattern in South Sumatra. First, children with mild glanular or coronal hypospadias often remain undiagnosed in rural communities. Families may see the condition as a benign cosmetic variant (frequently termed 'congenital circumcision') until school-age screening or pre-circumcision physical examination reveals the ventral urethral defect and hooded foreskin.[6] Second, Dr. Mohammad Hoesin Central General Hospital, the apex referral center for Southern Sumatra, selectively concentrates complex proximal and perineal cases. District hospitals across a large agricultural and coastal region refer them. In our cohort, 45.9% of parents worked as farmers, fishermen, or manual laborers, even though 70.2% had completed senior high school (37.8%) or university education (32.4%).[6] Perinatal history mattered too. In total, 67.6% (50/74) of preoperative patients had a history of preterm delivery (<37 weeks of gestation), and the share was especially large among proximal and perineal defects. Genetic and perinatal studies by Ajayi et al., Indriasari et al., Siregar et al., and Lestari et al. are consistent with a model in which early placental insufficiency, impaired human chorionic gonadotropin (hCG)-stimulated fetal Leydig cell steroidogenesis between 8 and 14 weeks of gestation, and preterm birth share a developmental pathway that may disproportionately arrest early proximal urethral fold fusion. This synthesis is the authors' inference; none of these studies measured placental function.[7,9,10,27]

Table 7 extends this comparison across global regions. Population-based birth registries and tertiary surgical cohorts look quite different. In North America and Western Europe, congenital hypospadias is diagnosed mainly in the neonatal nursery. Active birth-defect surveillance by Shan et al. and Lavoie et al. in the United States, and nationwide registry linkage by Leunbach et al. in Denmark, put anterior (glanular, coronal, and distal shaft) phenotypes at 85% to 91.5% of all cases.[3–5] Surgical repair in these systems is routinely completed between 6 and 18 months of age.[11,29] Few boys in Western nations therefore reach school age or adolescence with an uncorrected proximal or perineal urethra. The adult series of uncorrected hypospadias by Bush and Snodgrass in the United States and Leunbach et al. in Denmark consist mostly of mild distal or coronal variants, whose families chose non-operative management in infancy.[21,26] Tertiary hospital cohorts in Indonesia may reflect a two-stage healthcare filter. These include Saiful Anwar General Hospital in Malang (Henrizal et al., N = 250, 52.0% proximal),[6] Hasan Sadikin General Hospital in Bandung (Indriasari et al., median presentation age 7 years),[27] Dr. Soebandi Hospital in Jember (Lestari et al.),[10] and Dr. Mohammad Hoesin Central General Hospital in Palembang in the present study (N = 74, 59.5% proximal–perineal, 66.2% aged >5 years, mean age 7.70 ± 4.59 years). In rural and agrarian districts, where 45.9% of parents in our cohort are employed as farmers, fishermen, or manual laborers, mild glanular defects often go unrecognized until ritual circumcision at age 7 to 12 years. Severe proximal and perineal cases face geographical, financial, and administrative referral delays before they reach subspecialty pediatric urology care.[6]

Preterm birth (<37 weeks of gestation) was recorded in 67.6% (50/74) of preoperative patients, rising to 70.6% in proximal and 80.0% in perineal grades. This is compatible with the placental–androgen hypothesis of severe hypospadias, although gestational age was taken from maternal history and no placental or hormonal data were collected.[7–10,27] The timing matters. Between 8 and 14 weeks of gestation, masculine urethral fold tubularization is driven by placental human chorionic gonadotropin (hCG) acting on fetal Leydig cells. Fetal pituitary luteinizing hormone does not drive it, because that hormone matures later in mid-gestation.[7,27] Case-control and cohort studies in Indonesia by Indriasari et al., Siregar et al., and Lestari et al. agree on the main risk factors. So does the North American surveillance report by Shan et al. Al-Taher et al. in Jordan additionally implicated maternal body mass index, maternal age, and caffeine intake.[28] These studies identify low birth weight, preterm delivery, hormonal drug use, maternal environmental exposures, and maternal placental dysfunction as nongenetic risk factors for hypospadias.[3,9,10,27] Early chorionic villous hypoxia or uteroplacental vasculopathy may predispose the pregnancy to premature labor and blunt the first-trimester hCG–testosterone–DHT surge. Urethral fold closure then arrests at the penoscrotal or perineal junction. The distal corpus spongiosum and bulbospongiosus muscle stay splayed and hypoplastic.[7,12,14,27]

### *Anatomical and biomechanical considerations*

Our central finding is simple. Preoperative terminal dribbling is neither random nor purely post-surgical, and it rose monotonically with the congenital anatomical severity of hypospadias before any operative intervention. Across the four Hadidi grades, median terminal dribbling duration rose from 0 seconds in glanular and 3 seconds in distal hypospadias to 5 seconds in proximal and 7 seconds in perineal hypospadias (Kruskal–Wallis H = 22.829, p < 0.001, $\varepsilon^2$ = 0.313). Daily frequency rose from 0 and 2.5 episodes/day to 4 and 4.5 episodes/day (H = 18.704, p < 0.001, $\varepsilon^2$ = 0.256). Post-void urine drops increased from 0 and 2 drops to 4 and 6 drops per void (H = 23.054, p < 0.001, $\varepsilon^2$ = 0.316). Post-hoc pairwise Mann–Whitney U testing showed that glanular and distal cases formed a statistically homogeneous anterior group (all p ≥ 0.071), and proximal and perineal cases formed a homogeneous posterior group (all p ≥ 0.080). The anterior–posterior boundary behaved differently. Every cross-boundary comparison between anterior and posterior grades was significant (all p ≤ 0.007) (Table 3 and Figure 3).

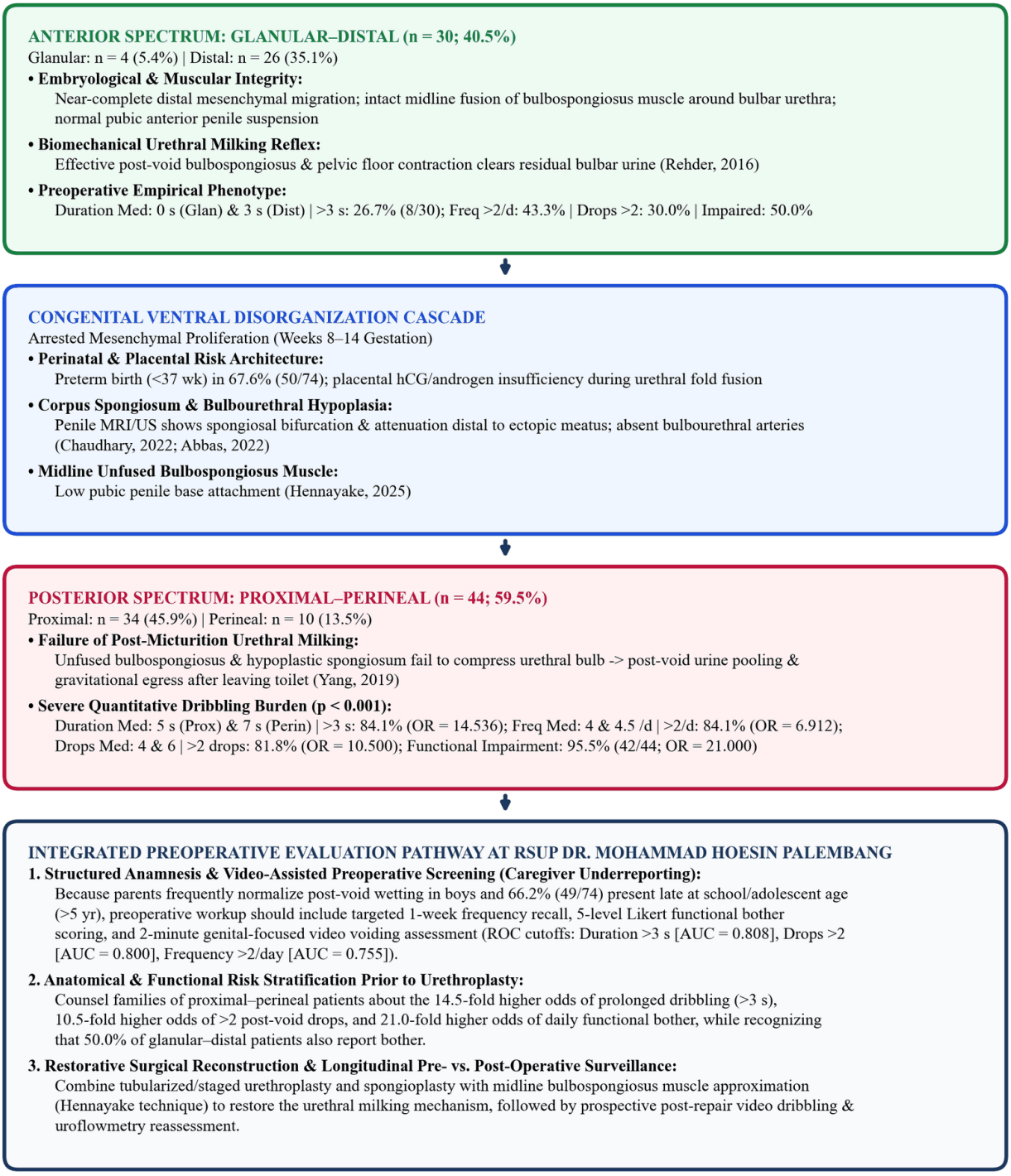


**Figure 6.** Pathophysiological biomechanics of congenital urethral milking failure and integrated preoperative clinical evaluation pathway in pediatric hypospadias: contrasting intact circumferential bulbospongiosus contraction and spongiosal pressure transmission in normal/anterior anatomy against midline unfused bulbospongiosus muscle, bifurcated/hypoplastic corpus spongiosum, low pubic penile base suspension, and post-void urethral pooling in proximal–perineal hypospadias, integrated with video-assisted terminal dribbling quantification (>3 s, >2/day, >2 drops) at RSUP Dr. Mohammad Hoesin Palembang.

The embryological and microstructural architecture of the male urethra, corpus spongiosum, and bulbospongiosus muscle may account for the difference in dribbling between anterior (glanular–distal) and posterior (proximal–perineal) hypospadias (Figure 6 and Table 7).[12–16] Consider normal anatomy first. In a normally developed male phallus, a vascularized cylinder of corpus spongiosum rich in elastic fibers completely encircles the urethra. The striated bulbospongiosus muscle invests the bulbar urethra ventrally and laterally. It is fused along a firm midline raphe and anchored to the perineal body and pubic arch.[13–16] When detrusor contraction ends and the external sphincter closes, the bulbospongiosus muscle contracts in rhythmic reflex waves. Together with the intrinsic elastic recoil of the sinusoidal corpus spongiosum, these contractions generate a centripetal squeezing wave (urethral milking). The wave propels residual bulbar and pendulous urine forward through the slit-like glanular meatus in less than one second.[14–17]

Congenital hypospadias looks different. High-resolution preoperative penile MRI studies by Chaudhary et al. and ultrasonographic evaluations by Abbas describe the spongiosal anatomy of the hypospadiac penis.[12,13] Microscopic and molecular analyses of the urethral plate by Tsachouridis et al. and Abdelhalim et al. report defective vascular organization and altered growth factor expression, and spongiosal compliance is thought to be reduced.[34,35] Two anatomical and post-pubertal functional investigations published in 2025 add to this. Hennayake et al. found that patients with severe proximal and perineal hypospadias have a congenital midline non-fusion of the bulbospongiosus muscle, together with a low, lax suspension of the penile base from the pubic bone.[14,15] The splayed muscle fibers lack a unified midline fulcrum. The hypoplastic proximal urethral floor lacks rigid spongiosal backing. The posterior urethra therefore acts as a low-compliance, adynamic sump at the end of micturition.[14,15] When detrusor pressure subsides, a large volume of urine stays pooled within the bulbar and proximal urethral segment. As the child stands or walks after voiding, gravity and passive wall relaxation make this trapped column of urine trickle slowly through the ectopic meatus. That meatus lacks the normal hydro-mechanical flow-focusing nozzle of the fossa navicularis and vertical glanular slit. This mechanism would be expected to produce prolonged terminal dribbling (>3 seconds; OR = 14.536), repeated daily episodes (>2/day; OR = 6.912), and high post-void drop counts (>2 drops; OR = 10.500) (Figure 6); the mechanism itself was not measured in this study.

The physical mechanics behind our statistical findings can be modeled with principles of fluid-structure interaction and urethral biomechanics (Figure 6). In a physiologically normal male lower urinary tract, sustained detrusor smooth muscle contraction drives voiding, coupled with synergistic relaxation of the striated external urethral sphincter and pelvic floor.[16,17] The trailing edge of the urine bolus passes through the membranous urethra into the bulbar segment as the bladder empties. The external sphincter then closes. Two active expulsive mechanisms engage at once. They clear the post-sphincteric urethral lumen.[14–17] First, the vascular sinusoids of the corpus spongiosum encase the urethra from the perineal membrane to the glans apex. They hold a dense network of elastin fibers and smooth muscle trabeculae. Passive and active circumferential elastic recoil collapses the urethral lumen into a zero-volume vertical slit.[12,13,16] Second comes muscle action. The midline-fused bulbospongiosus muscle (innervated by motor branches of the perineal nerve, S2–S4) contracts in rhythmic somatic reflexes. These contractions compress the urethral bulb upward and forward against the rigid fibrous fulcrum of the perineal body and Buck's fascia. The result is a rapid peristaltic-like pressure wave ('urethral milking') that accelerates the residual 1 to 2 mL of bulbar urine through the pendulous urethra and out of the conical fossa navicularis nozzle.[14–17]

In congenital hypospadias, each structural component of this urethral milking apparatus is progressively compromised as the meatus migrates posteriorly from the glans toward the perineum.[2,12–15] Chaudhary et al. used prospective pediatric penile MRI in 24 children. The bulbourethral vessel could not be visualized in 6 (25%), and only one child had a penoscrotal defect.[12] The microstructure tells the same story. High-frequency ultrasonographic mapping by Abbas showed the spongiosal anatomy,[13] and microscopic and molecular analyses of resected urethral plate and para-urethral tissues by Tsachouridis et al. and Abdelhalim et al. revealed more. Compared with normal urethral tissue, the urethral plate and para-urethral tissue in hypospadias showed diminished vascular density and altered epidermal growth factor (EGF) and transforming growth factor-beta (TGF-β) signaling.[34,35] Hennayake et al.'s 2025 intraoperative anatomical dissections showed that in proximal and perineal hypospadias, the two halves of the bulbospongiosus muscle may fail to fuse in the ventral midline. They stay laterally retracted along the ischiocavernosus crura. The suspension of the penile base from the pubic bones is lax and caudally displaced.[14,15]

**Table 7.** International Benchmarking Matrix Synthesizing Preoperative and Postoperative Anatomical, Urodynamic, and Terminal Dribbling Outcomes in Hypospadias Across Global Cohorts.

| Study, Year & Country | Study Design & Population | Anatomical Grading & Age Spectrum | Assessment Modality & Primary Endpoints | Key Quantitative Findings & Mechanistic Synthesis with Present Study |
|---|---|---|---|---|
| Present Study (Emirzon et al., 2026)<br>Palembang, Indonesia | Cross-Sectional Analytical<br>N = 74 Preoperative Pediatric Patients | Proximal: 45.9% (34) \| Distal: 35.1% (26)<br>Perineal: 13.5% (10) \| Glanular: 5.4% (4)<br>Age: 6–10 yr (36.5%), 11–18 yr (29.7%),<br>1–5 yr (21.6%), <1 yr (12.2%); Preterm: 67.6% | Video-Assisted Stopwatch Duration,<br>Dual-Rater Drop Count, 1-Week Frequency,<br>5-Level Likert Functional Impairment | Overall Medians: Duration 4.0 s (mean 4.71 ± 3.54 s), Frequency 3.0 /day (3.05 ± 1.71), Drops 3.0 (3.64 ± 2.98). Kruskal–Wallis H = 22.829, 18.704, 23.054 (all $p < 0.001$). ROC Cutoffs: >3 s (AUC = 0.808, OR = 14.536), >2 drops (AUC = 0.800, OR = 10.500), >2 /day (AUC = 0.755, OR = 6.912). Functional impairment OR = 21.000 ($p < 0.001$). |
| Hennayake et al. (2025)[14,15]<br>United Kingdom | Anatomical & Post-Pubertal Surgical Cohort Series<br>Proximal Hypospadias | Severe Proximal / Penoscrotal Hypospadias Evaluated Intraoperatively & Post-Pubertally | Intraoperative Bulbospongiosus Mapping<br>& Post-Pubertal Urinary Stream,<br>Terminal Dribbling & Ejaculation | Reported congenital midline non-fusion of the bulbospongiosus muscle and low pubic penile base suspension in proximal hypospadias; targeted bulbospongiosus reconstruction was followed by a patient-reported strong stream without dribbling in 95.4% and normal ejaculation in 94.4% after puberty (22 patients), in line with a role of the bulbospongiosus muscle in terminal emptying. |

| Study, Year & Country | Study Design & Population | Anatomical Grading & Age Spectrum | Assessment Modality & Primary Endpoints | Key Quantitative Findings & Mechanistic Synthesis with Present Study |
|---|---|---|---|---|
| Chaudhary et al. (2022)[12] India | Prospective Pediatric Penile MRI Study Hypospadias Cohort | Children aged 5 years or older with hypospadias (mostly coronal and subcoronal; one penoscrotal) | High-Resolution Penile Magnetic Resonance Imaging of Corpus Spongiosum & Bulbourethral Vessels | Penile MRI in 24 children: the bulbourethral vessel was not visualized in 6 (25%); one child had a penoscrotal defect. The findings are compatible with reduced spongiosal support in more severe disease, which this study did not measure. |
| Bush & Snodgrass (2023)[21] United States | Observational Clinical Series Uncorrected Distal Hypospadias | Adult Men with Untreated Distal Hypospadias Presenting for Evaluation | Structured Functional Voiding & Sexual Complaint Assessment | Reported that 81% of uncorrected distal hypospadias patients experienced urinary spraying and nearly all reported at least one functional bother, aligning with our finding that 50.0% (15/30) of glanular–distal children already experience mild-to-moderate functional impairment from post-void dribbling. |
| Bohane et al. (2025)[22] & Schlomer et al. (2014)[20] Multicenter / USA | Scoping Review & Cross-Sectional Survey of Uncorrected Hypospadias | Mild/Distal vs. Severe/Proximal Untreated Hypospadias Spectrum | IPSS, Urinary Stream Deviation, Sitting to Void & Quality of Life | Confirmed a marked severity gradient: uncorrected proximal/severe hypospadias exhibited significantly worse IPSS urinary scores, sitting-to-void necessity, and functional bother than distal cases, mirroring our 21.0-fold higher odds of functional impairment in proximal–perineal versus glanular–distal patients. |
| Moriya et al. (2007)[19] Japan | Norm-Related Survey of Young Men Operated in Childhood | Hypospadias Operated in Childhood (Age 18–26 yr) vs. Controls | Self-Reported LUTS, Terminal Dribbling & Urethral Milking Maneuver | Moderate-to-severe terminal dribbling occurred in 32% of men operated in childhood vs. 3% of controls; urethral squeezing was needed by 36% of severe cases vs. 0% of mild cases. This is the benchmark used for our sample-size calculation; it comes from postoperative adults, not from untreated children. |
| Sikchi et al. (2023)[30] & Tsachouridis et al. (2026)[31] India & Netherlands | Preoperative Uroflowmetry vs. Controls (Sikchi); 12-Year Post-Repair Cohort (Tsachouridis) | Preoperative Children (Sikchi); Boys After Repair, Prepubertal to Pubertal (Tsachouridis) | Objective Uroflowmetry (Qmax, Flow Curve Shape) | Sikchi et al. identified abnormal preoperative uroflowmetry in hypospadias before any surgical correction; Tsachouridis et al. showed that uroflowmetry patterns after repair evolve from childhood through puberty. Together they support combining objective uroflowmetry with our video-assisted dribbling metrics. |
| Leunbach et al. (2025)[5] & Henrizal et al. (2025)[6] Denmark & Indonesia | Nationwide Registry (N = 9,189) vs. Indonesian Tertiary Series (N = 250) | Population-Based Distal (91.5%) vs. Tertiary Referral Proximal (52.0%) | Epidemiological Subtype Distribution & Age at Clinical Presentation | Explains why nationwide birth registries are dominated by distal hypospadias (91.5%), whereas Indonesian tertiary referral centers concentrate proximal/severe cases (52.0% in Malang; 59.5% proximal–perineal in our Palembang cohort) and late school-age/adolescent presentations. |

*Abbreviations: AUC, area under the receiver operating characteristic curve; IPSS, International Prostate Symptom Score; LUTS, lower urinary tract symptoms; MRI, magnetic resonance imaging; OR, odds ratio; Qmax, maximum urinary flow rate; ROC, receiver operating characteristic.*

From a hydrodynamic standpoint, the proximal hypospadiac urethra changes from an active muscular conduit into a compliant, thin-walled, adynamic reservoir (sump). Midline bulbospongiosus fusion and circumferential corpus spongiosum investment are absent.[14–17] The law of Laplace ($T = P \times r / h$, where T is wall tension, P is intraluminal fluid pressure, r is luminal radius, and h is wall thickness) offers a conceptual model here; none of these quantities was measured in this study. A thin-walled (low h) proximal urethra without ventral spongiosal and muscular support distends radially during voiding. It fails to recoil when detrusor pressure falls to zero.[16,17] Poiseuille's hydrodynamic relationship ($Q = [\pi \times \Delta P \times r^4] / [8 \times \eta \times L]$) adds a second constraint. Active bladder pressure (ΔP) ceases at the end of micturition, and no bulbospongiosus squeezing pressure is generated. Residual urine trapped within the bulbar and proximal urethral sump can then exit only under the negligible hydrostatic pressure of gravity.[17,18] The ectopic proximal or perineal meatus also lacks the streamlined, slit-like flow-focusing geometry of the normal glanular fossa navicularis. Surface tension therefore makes the slowly exiting fluid coalesce along the ventral penile and scrotal skin into discrete sequential drops (median 4 drops in proximal and 6 drops in perineal cases, up to 15 drops/void) over a prolonged interval (median 5 seconds in proximal and 7 seconds in perineal cases, up to 20 seconds) (Table 3 and Figure 6).

### *ROC thresholds, quality of life and surgical implications*

We applied receiver operating characteristic (ROC) curve analysis to the video-assisted and recall-verified measurements. This study derived exploratory cutoffs relating terminal dribbling metrics to posterior (proximal–perineal) hypospadias. They are descriptive, not diagnostic, because the grade is observed directly at examination; they were derived and evaluated in the same sample and need external validation. They were dribbling duration >3 seconds (AUC = 0.808, sensitivity 84.09%, specificity 73.33%, accuracy 79.73%), post-void drops >2 drops per void (AUC = 0.800, sensitivity 81.82%, specificity 70.00%, accuracy 77.03%), and daily frequency >2 episodes/day (AUC = 0.755, sensitivity 84.09%, specificity 56.67%, accuracy 72.97%). Video-measured duration (AUC = 0.808) and dual-rater drop count (AUC = 0.800) outperformed caregiver-reported daily frequency (AUC = 0.755). A likely reason is a measurement difference. Direct video-timed observation captures the instantaneous hydrodynamic consequence of urethral pooling during a single standardized void. 1-week frequency recall is partly modulated by daily fluid intake, school voiding schedules, and parental observation opportunities.[17,18]

Preoperative terminal dribbling also bears on daily functional bother and quality of life. In our cohort, 95.5% (42/44) of children with proximal–perineal hypospadias experienced daily functional impairment (Scores 2–5), and 75.0% (33/44) suffered moderate-to-severe bother (Scores 3–5). Among children with glanular–distal hypospadias, the figures were 50.0% (15/30) and 10.0% (3/30), so the unadjusted OR was 21.000 (aOR = 23.920) for any impairment and 27.000 (aOR = 26.013) for moderate-to-severe impairment (Table 6). Our data also show that anterior hypospadias is not entirely asymptomatic. Exactly half (15/30) of glanular–distal patients reported at least mild functional bother, and 26.7% to 30.0% exceeded the >3-second and >2-drop thresholds. The finding links two sets of observations. Bush and Snodgrass reported that 81% of men with uncorrected distal hypospadias experience urinary spraying or stream deflection. Schlomer et al. and Bohane et al. conducted comparative surveys, which showed that functional complaints exist in uncorrected distal defects but that urinary bother and the need to sit during

voiding rise sharply in proximal phenotypes.[20–22] In a school-age Indonesian population (66.2% of our patients were aged 6–18 years), terminal dribbling of 5 to 20 seconds and 4 to 15 post-void drops directly wets clothing after toilet use. It also interferes with ritual purity (taharah) required for daily Islamic prayers. Peer stigma and social withdrawal may follow. These burdens parallel the appearance-related and voiding-related bother described by Ruppen-Greeff et al., Bhatia et al., and Leunbach et al., whereas Wirmer et al. reported high satisfaction and average quality of life after childhood repair.[23–26]

Our findings bear on operative planning and long-term follow-up in reconstructive surgery. Post-urethroplasty terminal dribbling, urethral diverticula, and late functional complications remain frequent challenges after hypospadias repair, especially when long neourethral tubes are constructed without adequate muscular and spongiosal support.[36–46] Documenting severe preoperative terminal dribbling therefore alerts the reconstructive urologist to underlying bulbospongiosus non-fusion and corpus spongiosum hypoplasia before surgery begins. Hennayake et al. championed anatomical midline approximation of the bulbospongiosus muscle, pubic base stabilization, and vascularized corpus spongiosum or dartos spongioplasty during primary or two-stage repair. Their targeted bulbospongiosus reconstruction achieved a 95.4% post-pubertal terminal-dribbling-free rate.[14,15] This is a biologically rational strategy. It restores active urethral milking alongside neourethral tubularization.

A closer look at the contingency and regression models (Tables 4, 5, and 6) gives several methodological insights that help interpret these exploratory thresholds. First, the post-hoc Mann–Whitney U pairwise matrix (Table 3) justifies dichotomizing the four Hadidi grades into anterior (glanular–distal, n = 30) and posterior (proximal–perineal, n = 44) groups. The four-tier Kruskal–Wallis tests showed significant overall rank differences ($H = 22.829$, 18.704, and 23.054; all $p < 0.001$). However, analyzing categorical cutoffs in 4 × 2 or 4 × 5 tables inevitably introduces sparse expected cell counts (<5) in the glanular (n = 4) and perineal (n = 10) columns. Glanular versus distal comparisons were statistically non-significant across all three parameters ($p = 0.123$, 0.071, and 0.108). Proximal versus perineal comparisons were likewise non-significant ($p = 0.368$, 0.160, and 0.080). Collapsing the four grades along the anterior–posterior embryological boundary therefore avoided sparse expected counts in the 2 × 2 tables (minimum expected counts of 11.76, 9.73, 11.76, and 6.89). Second, Table 5 presents row percentages (positive and negative predictive values within symptom strata) alongside column percentages (sensitivity and specificity within anatomical grades). This resolves a common source of ambiguity in clinical epidemiology. Among all children presenting with prolonged dribbling >3 seconds (n = 45), 82.2% (37/45; PPV) have proximal–perineal hypospadias. Among all children with proximal–perineal hypospadias (n = 44), 84.1% (37/44; sensitivity) exhibit dribbling >3 seconds. Third, the multivariable logistic regression models controlled for patient chronological age and parental educational attainment. After that adjustment, posterior hypospadias grading remained associated with prolonged dribbling >3 seconds (aOR = 19.607, 95% CI: 5.29–72.60), post-void drops >2 (aOR = 13.339, 95% CI: 3.91–45.48), daily frequency >2/day (aOR = 6.749, 95% CI: 2.18–20.92), any functional impairment (aOR = 23.920, 95% CI: 4.27–133.93), and moderate-to-severe functional impairment (aOR = 26.013, 95% CI: 6.27–107.96).

These functional and surgical findings fit the broader international literature, which suggests that preoperative terminal dribbling assessment merits consideration as a component of hypospadias evaluation (Table 7).[19–26,30,31,36–46] Sikchi et al. performed preoperative uroflowmetry studies in India. They found that children with uncorrected hypospadias already show flattened, prolonged uroflow curves and reduced maximum flow rates (Qmax) before surgery.[30] Tsachouridis et al. followed boys in the Netherlands for 12 years after repair and showed that uroflowmetry patterns evolve substantially from childhood through puberty.[31] Large surgical outcome series and meta-analyses add to this. They include Anttila et al. in Finland, Roshandel et al. in Iran, Zhou et al. and Ye et al. in China, Cousin et al. and Hild et al. in France, Zharkimbayeva et al. in Kazakhstan, Scougall et al. in the international registry, Skott et al. in Denmark, and Gaines and Simhan in the United States. These reports describe complication and re-operation rates of 30% to 58% after proximal hypospadias repair.[36,39,40,42,43] Fistula, neourethral diverticulum, strictures, and urine-stream problems are described as long-term morbidities.[39,40,45,46] Dale et al. in the United Kingdom reported that early complications depend on age at repair.[38] Voiding outcome after penoscrotal repair is judged by micturition time, urinary stream, and post-void dribbling, and about 95% of 160 children had good urinary function in a randomized series.[47] In adolescents operated on in childhood, suboptimal voiding was found in 22.1%, and proximal hypospadias was associated with a suboptimal urinary outcome.[48] A long neourethra may be constructed via tubularized incised plate [TIP], onlay island flap, or staged buccal mucosal graft urethroplasty. If the splayed corpus spongiosum and unfused bulbospongiosus muscle are not reconstructed, the new skin or mucosal tube is expected to lack active muscular expulsion and may lengthen the adynamic post-sphincteric sump.[14,15,39–41] Hennayake et al. took a different approach during proximal hypospadias repair. They mobilized and re-approximated the splayed bulbospongiosus muscle in the ventral midline and suspended the penile base to the pubic periosteum. In 22 patients evaluated after puberty, 95.4% described a strong stream without dribbling and 94.4% described normal ejaculation (patient-reported).[14,15] Our preoperative video-assisted protocol may thus identify children with severe dribbling (>3 seconds, >2 drops, >2 episodes/day). Such children may stand to benefit from anatomical bulbospongiosus myoplasty and spongioplasty during definitive reconstruction, as well as from structured postoperative pelvic floor and urethral milking rehabilitation.

### *Strengths and limitations*

The primary strengths are prospective consecutive enrollment, with 100.0% data completeness across 74 untreated pediatric patients, and objective measurement. Smartphone video frame timing and two-rater drop counting were intended to reduce observer bias. The biostatistical framework combined exact nonparametric rank tests, DeLong ROC threshold optimization, and multivariable logistic regression adjusted for age and parental education. Limitations remain. First, the cross-sectional design captures preoperative associations at a single time point and cannot directly evaluate longitudinal changes in terminal dribbling following surgical reconstruction. Prospective pre- versus post-urethroplasty follow-up of this cohort is warranted. Second, the glanular subgroup was small (n = 4; 5.4%). This reflects tertiary referral filter bias, wherein simple glanular anomalies rarely reach subspecialty surgical clinics. Our dichotomized glanular–distal (n = 30) versus proximal–perineal (n = 44) analysis still provided adequate cell counts (minimum expected count ≥ 6.89 in all 2 × 2 tables), but multicenter studies incorporating primary and secondary hospitals would broaden representation of mild glanular defects. Third, video-assisted stopwatch timing and dual-rater

drop counting are practical, non-invasive, clinic-ready objective metrics. Even so, simultaneous electronic uroflowmetry (measuring maximum flow rate Qmax, average flow rate Qave, voided volume, and flow curve morphology) was not performed, and neither was high-frequency perineal ultrasonography of bulbospongiosus contraction thickness. Both should be integrated into future multimodal protocols.[30,31] Further limitations are the reliance on caregiver recall and reporting, including for infants and toddlers; the uncertain validity of the bother scale; the derivation and evaluation of the ROC cutoffs in the same sample, which makes them optimistic; the absence of a multiplicity correction; the benchmark proportion for the sample size, which came from adults operated in childhood; and the lack of data on meatal stenosis, phimosis, circumcision, and chordee.

Fourth, our multivariable logistic regression models controlled for chronological age and parental educational attainment. Additional anatomical covariates were not incorporated into the regression models. These were exact glans diameter (mm), urethral plate width (mm), degree of ventral chordee curvature (degrees), and the composite Glans-Urethral Meatus-Shaft (GMS) score. Future multicenter protocols such as the PREDICT-H framework (a registered study protocol) should evaluate them.[49] Finally, longitudinal tracking of this 74-patient Palembang cohort at 3, 6, 12, and 24 months post-urethroplasty is needed. It would pair our video-assisted terminal dribbling stopwatch and drop-count protocol with standardized uroflowmetry, post-void residual ultrasound, and validated cosmetic scoring, and it will show the extent to which modern reconstructive techniques normalize preoperative terminal dribbling across the pediatric age spectrum.

## 5. Conclusion

Preoperative hypospadias grading is monotonically associated with the severity of terminal dribbling and resulting daily functional impairment in pediatric patients at Dr. Mohammad Hoesin Central General Hospital, Palembang. Proximal hypospadias was the predominant anatomical grade (45.9%), followed by distal (35.1%), perineal (13.5%), and glanular (5.4%) grades. Overall cohort medians were 4.00 seconds for dribbling duration (mean 4.71 ± 3.54 s), 3.00 episodes/day for daily frequency (mean 3.05 ± 1.71/day), and 3.00 drops for post-void urine drops (mean 3.64 ± 2.98 drops). Daily functional impairment was reported by 77.0% of patients. Across the four anatomical grades, terminal dribbling duration (Kruskal–Wallis $H = 22.829$, $p < 0.001$), daily frequency ($H = 18.704$, $p < 0.001$), and post-void urine drops ($H = 23.054$, $p < 0.001$) increased significantly from anterior to posterior phenotypes. Pairwise Mann–Whitney U analysis confirmed homogeneity within anterior (glanular vs. distal) and posterior (proximal vs. perineal) pairs and divergence across the anterior–posterior boundary. Receiver operating characteristic (ROC) curve analysis yielded exploratory cutoffs for three measures. The cutoffs were >3 seconds for dribbling duration (AUC = 0.808, $p < 0.001$; crude OR = 14.536, aOR = 19.607), >2 drops for post-void urine drops (AUC = 0.800, $p < 0.001$; crude OR = 10.500, aOR = 13.339), and >2 episodes/day for daily frequency (AUC = 0.755, $p < 0.001$; crude OR = 6.912, aOR = 6.749). Proximal–perineal grading was associated with a 21.000-fold higher odds of daily functional impairment (95.5% vs. 50.0%, $p < 0.001$; aOR = 23.920). Preoperative screening of terminal dribbling by standardized video-assisted timing and drop counting merits consideration in pediatric hypospadias evaluation, to inform family counseling, to help plan spongioplasty and bulbospongiosus reconstruction, and to provide a quantitative baseline for postoperative functional assessment. These associations persisted after adjustment for patient age and parental education. Dribbling longer than 3 seconds, more than 2 post-void drops, and more than 2 daily episodes may therefore be informative descriptors of posterior phenotypes; their link to corpus spongiosum and bulbospongiosus function was not measured and needs further study.

## 6. Declarations

### *Ethics Approval and Consent to Participate*

The study adhered to the Declaration of Helsinki. It received institutional ethical clearance from the Health Research Ethics Committee of Dr. Mohammad Hoesin Central General Hospital, Palembang, Indonesia (Approval number: DP/04.03/D.XVII.9.4//ETIK/318/2026). Written informed consent was obtained from the parents or legal guardians of all participating patients before clinical examination and standardized video-assisted voiding evaluation.

### *Consent for Publication*

Written informed consent was obtained from parents or legal guardians; no identifiable individual patient photographs or personal identifiers are published in this article.

### *Availability of Data and Materials*

All statistical summaries, contingency distributions, and receiver operating characteristic coordinates generated or analyzed during this study are included in the published tables and figures; de-identified analytical records are available from the corresponding author upon reasonable request.

### *Artificial Intelligence Use Statement*

None.

### *Author Contribution Statement*

M.F.O.E.: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing. M.H.: Conceptualization, Methodology, Supervision, Validation, Writing – review & editing. P.: Methodology, Supervision, Formal analysis, Validation, Writing – review & editing. All authors read and approved the final manuscript.

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### *Conflict of Interest / Competing Interests*

The authors declare that they have no competing financial or non-financial interests.

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