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Long-term bowel and urinary function after posterior sagittal anorectoplasty: Clinical predictors

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Abstract:
Long-term bowel and urinary dysfunction may persist after posterior sagittal anorectoplasty. A modeled cohort of 130 children underwent standardized bowel and urinary assessment. Good bowel function occurred in 74 (56.9%) and favorable urinary function in 99 (76.2%). Complex anatomy, sacral/spinal abnormalities and early complications were associated with poor outcomes. Thus, coordinated colorectal and urological follow-up may help individualize rehabilitation.

Keywords: Anorectal malformation, posterior sagittal anorectoplasty, bowel function, urinary function, fecal continence, long-term outcome

Background:
Anorectal malformations are a diverse group of congenital abnormalities of the distal bowel and its association with the urinary and genital tracts. Although anatomical correction and survival are much improved with modern reconstructive surgery, the long-term success cannot be assessed by the appearance of the perineum alone. Constipation, fecal soiling, impaired voluntary bowel control, urinary incontinence, recurrent urinary tract infection, bladder dysfunction and psychosocial burden can also be seen in adolescence and adulthood. Functional outcomes and life-long multi-disciplinary care are thus becoming more important in contemporary management **[1]**. Standardized anatomical terminology and outcome reporting is crucial as functional potential varies widely between malformation types. The introduction of standard classification, documentation of related anomalies and the adoption of common bowel outcome categories have been encouraged internationally **[2]**. Although the posterior sagittal anorectoplasty offers direct visualization of the sphincter complex and continues to be the key to the repair of many malformations, the operation does not remove the effects of the level of the rectal fistula, the intrinsic motility of the colon, the urinary tract pathology, the spinal cord abnormalities, or the effects of sacral development. Early prediction of children's continence is challenging. Functional outcome is related to anatomy, neuromuscular integrity, bowel consistency, toilet training, constipation management, adherence and social factors. Based on large clinical datasets, it has been suggested that anatomical and associated features can be used to predict a child's ability to control their faeces, but this is not a definite prediction **[3]**. Apparently normal children can become very constipated and soiled and selected children with complex malformations can attain good social continence when bowel management is tailored to the individual. Recent multicenter studies have showed that bowel function in early childhood is not uniform even within each anatomical subtype and is related to constipation, treatment and patient characteristics **[4]**. Data from referral centres also demonstrate significant variations in faecal continence, highlighting the need for a standardised follow-up and access to specialist colorectal care **[5]**. Long-term follow-up studies into adolescence and adulthood have shown that long-term bowel and urinary morbidity remains after successful reconstruction **[6]**. Urinary function should be given the same consideration. Renal, ureteral, bladder, spinal and sacral abnormalities may have a separate effect on continence and renal health, apart from the anorectal repair. Long-term urological follow-up has shown that a significant proportion of patients have bladder dysfunction, incontinence, urinary tract infection and impaired emptying, which requires treatment **[7]**. Systematic evidence also suggests that urinary outcomes are inconsistently reported and may persist into adulthood **[8]**. Therefore, it is of interest to evaluate the long-term bowel and urinary function after posterior sagittal anorectoplasty and identify early clinical, anatomic, neurologic, urologic and post-operative predictors of poor outcome.

Materials and Methods:
Study design and participants:
A prospective observational model was constructed for a high-volume paediatric colorectal and urology programme. Children were eligible if they had undergone a congenital anorectal malformation repair that was primarily performed using posterior sagittal anorectoplasty, had at least 4 years of follow-up after the surgery and were able to undergo a standardized bowel and urinary assessment with a parent/caregiver. The modeled analytic cohort comprised 130 children. All participant-level data are synthetic and were generated for the purpose of research-planning and education only and no actual patients were enrolled. Children were not included if the anorectal malformation had been treated without a posterior sagittal component, severe global neurodevelopmental impairment made functional assessment difficult, major unrelated neurological disease was the reason for assessing bowel or urinary function, or follow-up data was incomplete. Children with spinal dysraphism that was intrinsic to the congenital anomaly spectrum were included as there was a prespecified predictor of spinal status.

Anatomical and clinical factors:
Malformations were classified into favorable, intermediate and complex functional groups based on the anticipated relationship of the rectum to the sphincter complex and the presence of cloacal or very high fistulous anatomy. Perineal and selected vestibular fistulas were included in the favorable group, rectobulbar and rectoprostatic fistulas and other malformations with moderate functional risk were included in the intermediate group and rectobladder-neck fistula, cloacal malformation, no fistula with high rectal pouch and severe associated pelvic anatomy were included in the complex group. The following candidate predictors were from the longitudinal record: sex, age at definitive repair, staged versus primary repair, malformation complexity, associated genitourinary anomaly, sacral ratio, sacral anomaly, tethered cord or other clinically relevant spinal dysraphism, post-operative wound complication, anal stenosis

requiring repeated dilatation or revision, severe constipation by two years of age and recurrent febrile urinary tract infection during the first two years after reconstruction.

Bowel function assessment:
Bowel function was evaluated using structured history and the Rintala Bowel Function Score, as well as standardized reporting of voluntary bowel movements, soiling and constipation. This score included defecation control, urge to defecate, frequency, soiling, accidents, constipation and social issues. Good bowel function was defined as a score of 17 or higher and not having grade 2 or 3 soiling. Laxatives, enemas, transanal irrigation or antegrade continence enema (ACE) were recorded separately and not necessarily indicative of a poor outcome if an otherwise continent child was using these. Constipation was considered if the child had a history of difficult or infrequent bowel movements that needed to be treated regularly and severe early constipation was defined as having had repeated impaction or megarectum, or having been on medication for constipation before age 2 years. Soiling was rated as occasional minor staining to daily accidents with significant social impact.

Urinary function assessment:
The urinary status was assessed using a structured symptom inventory including daytime frequency, urgency, wetting, straining, weak stream, incomplete emptying and holding behavior. Developmentally appropriate, a Dysfunctional Voiding Symptom Score was calculated. Favorable urinary function was defined as no regular urinary incontinence and no requirement for clean intermittent catheterization and a urinary symptom score below the abnormal threshold that is age-and sex-specific. All children were assumed to have blood pressure measurement, urinalysis, serum creatinine (if clinically indicated) and renal and bladder ultrasonography. Uroflowmetry and postvoid residual measurement were reserved for children with persistent incontinence, recurrent infection, suspected retention, hydronephrosis and known neurospinal disease and urodynamic testing was reserved for children with persistent incontinence and suspected neurospinal disease. Recurrent febrile UTI was defined as having two or more episodes of febrile UTI with a positive urine culture.

Follow-up and outcomes:
They underwent a baseline comprehensive evaluation and were followed for 12 months to validate treatment needs, infection rates and bowel and urinary classification stability. Good bowel function and favourable urinary function at the final evaluation were the primary outcomes. Secondary outcomes were voluntary bowel movements, grade 2-3 soiling and regular treatment of constipation, recurrent UTI, clean intermittent catheterization and requirement for a formal bowel management program.

Statistical analysis:
Continuous variables were presented as means ± SD or median (interquartile range). Categorical variables were presented as number and percentages. Continuous data were compared among the three malformation-complexity groups by analysis of variance and categorical data were compared by chi-square or Fisher exact test. Multivariable logistic regression models were created separately for poor bowel function and poor urinary function. Univariable $p<0.10$ and clinically important anatomical factors were entered as candidate variables and checked for collinearity. Odds ratios and 95% confidence intervals were reported, adjusting for the variables shown. Two-sided $p<0.05$ was considered statistically significant. The synthetic data set was internally checked for consistency of all percentages, group comparisons and regression results throughout the manuscript.

Results:
The modeled cohort comprised 130 children (mean age, 8.6 ± 2.4 years), including 74 boys (56.9%), distributed into favorable (n=47), intermediate (n=52) and complex (n=31) anatomic groups. **Table 1** shows the greater frequency of associated risk features with increasing complexity. Staged repair occurred in 12 (25.5%), 32 (61.5%) and 24 (77.4%) children across the three groups ($p<0.001$). A sacral ratio <0.60 was present in 3 (6.4%), 10 (19.2%) and 14 (45.2%) ($p<0.001$); tethered cord or spinal dysraphism in 3 (6.4%), 8 (15.4%) and 11 (35.5%) ($p=0.002$). Genitourinary anomalies occurred in 9 (19.1%), 20 (38.5%) and 20 (64.5%), respectively ($p<0.001$). Severe constipation by age two was progressively more frequent (17.0%, 34.6% and 58.1%; $p<0.001$), whereas the between-group comparison for postoperative anal stenosis did not reach significance ($p=0.11$). The bowel-function outcomes in **Table 2** worsened in parallel with anatomic complexity. Mean Bowel Function Score was 17.6 ± 2.2 in the favorable group, 16.1 ± 3.0 in the intermediate group and 12.9 ± 3.8 in the complex group ($p<0.001$). Good bowel function was present in 35/47 (74.5%), 30/52 (57.7%) and 9/31 (29.0%) children, respectively ($p<0.001$), giving 74 of 130 (56.9%) overall. Voluntary bowel movements were reported by 41 (87.2%), 38 (73.1%) and 15 (48.4%) children. Grade 2–3 soiling rose from 12.8% to 30.8% and 51.6% and regular constipation treatment from 34.0% to 48.1% and 67.7% ($p=0.013$ for constipation treatment). Urinary outcomes are also summarized in **Table 2**. Favorable urinary function occurred in 42 (89.4%) children with favorable anatomy, 40 (76.9%) with intermediate anatomy and 17 (54.8%) with complex anatomy ($p<0.001$), totaling 99 (76.2%). Persistent urinary symptoms were reported in 5 (10.6%), 12 (23.1%) and 16 (51.6%) children ($p<0.001$), totaling 33 (25.4%). Recurrent febrile urinary tract infection increased from 2 (4.3%) to 6 (11.5%) and 9 (29.0%; $p=0.003$). Clean intermittent catheterization was required by none, 3 (5.8%) and 6 (19.4%) children, respectively ($p=0.002$). Persistent symptoms and the composite definition of favorable urinary function are separate endpoints and should not be treated as exact numerical complements. Multivariable associations in **Table 3** identify five predictors of poor bowel function: complex anorectal malformation (OR 3.82, 95% CI 1.52–9.63), sacral ratio <0.60 (OR 4.19, 1.66–10.58), tethered cord (OR 3.07, 1.18–7.98), severe constipation before age two (OR 2.91, 1.30–6.49) and postoperative anal stenosis (OR 2.47, 1.01–6.06). For poor urinary

function, independent predictors were associated genitourinary anomaly (OR 4.48, 1.85–10.86), tethered cord (OR 3.71, 1.42–9.70), recurrent early febrile urinary tract infection (OR 3.02, 1.12–8.15) and sacral ratio <0.60 (OR 2.63, 1.04–6.64). These associations are reported in **Table 3** and do not establish direct causality.

Table 1: Baseline and anatomical characteristics by malformation complexity

Characteristic	Favorable (n=47)	Intermediate (n=52)	Complex (n=31)	p value
Age at assessment, years	8.4 ± 2.3	8.7 ± 2.5	8.8 ± 2.4	0.74
Male sex	18 (38.3)	35 (67.3)	21 (67.7)	0.006
Staged repair	12 (25.5)	32 (61.5)	24 (77.4)	<0.001
Sacral ratio <0.60	3 (6.4)	10 (19.2)	14 (45.2)	<0.001
Tethered cord/spinal dysraphism	3 (6.4)	8 (15.4)	11 (35.5)	0.002
Associated genitourinary anomaly	9 (19.1)	20 (38.5)	20 (64.5)	<0.001
Severe constipation by age 2 years	8 (17.0)	18 (34.6)	18 (58.1)	<0.001
Postoperative anal stenosis	4 (8.5)	8 (15.4)	8 (25.8)	0.11

Values are presented as n (%) or mean ± SD unless otherwise stated. P values are two-sided.

Table 2: Long-term bowel and urinary outcomes by malformation complexity

Outcome	Favorable (n=47)	Intermediate (n=52)	Complex (n=31)	p value
Bowel Function Score	17.6 ± 2.2	16.1 ± 3.0	12.9 ± 3.8	<0.001
Good bowel function	35 (74.5)	30 (57.7)	9 (29.0)	<0.001
Voluntary bowel movements	41 (87.2)	38 (73.1)	15 (48.4)	<0.001
Grade 2-3 soiling	6 (12.8)	16 (30.8)	16 (51.6)	<0.001
Regular constipation therapy	16 (34.0)	25 (48.1)	21 (67.7)	0.013
Favorable urinary function	42 (89.4)	40 (76.9)	17 (54.8)	<0.001
Persistent urinary symptoms	5 (10.6)	12 (23.1)	16 (51.6)	<0.001
Recurrent febrile UTI	2 (4.3)	6 (11.5)	9 (29.0)	0.003
Clean intermittent catheterization	0 (0.0)	3 (5.8)	6 (19.4)	0.002

Values are presented as n (%) or mean ± SD unless otherwise stated. P values are two-sided.

Table 3: Independent predictors of poor long-term bowel and urinary function

Outcome and predictor	Adjusted OR	95% CI	p value
Poor bowel: complex ARM	3.82	1.52-9.63	0.004
Poor bowel: sacral ratio <0.60	4.19	1.66-10.58	0.002
Poor bowel: tethered cord	3.07	1.18-7.98	0.021
Poor bowel: severe constipation by age 2	2.91	1.30-6.49	0.009
Poor bowel: postoperative anal stenosis	2.47	1.01-6.06	0.048
Poor urinary: GU anomaly	4.48	1.85-10.86	0.001
Poor urinary: tethered cord	3.71	1.42-9.70	0.008
Poor urinary: recurrent early febrile UTI	3.02	1.12-8.15	0.029
Poor urinary: sacral ratio <0.60	2.63	1.04-6.64	0.041

Values are presented as n (%) or mean ± SD unless otherwise stated. P values are two-sided.

Discussion:

This prospective observational study indicates that the long-term function after posterior sagittal anorectoplasty is not solely attributable to the surgery. Malformation complexity, sacral and spinal development, associated genitourinary disease and early childhood clinically recognizable events were strongly related to bowel and urinary outcomes. Just over half had good bowel function and about three quarters had good urinary function. Children who had good anatomy had significantly better outcomes compared to children who had complex malformations. The bowel results are examples of anatomical reconstruction versus functional rehabilitation. Posterior sagittal exposure allows for exact placement of the rectum within the sphincter complex; however, other factors such as sensation, muscle quality, sacral innervation, colonic motility, stool consistency and the ability to manage constipation are also important to maintain continence. Previous and current series with standardized outcome systems have reported ongoing soiling and constipation post-reconstruction and these outcomes have been worse in anatomically complex malformations **[9]**. Posterior sagittal long-term reviews also highlight those functional problems may remain following a technically successful repair **[10]**. In the current model, the complexity of the malformations was an independent predictor of poor bowel function. This is to be expected as there is often a less favorable sphincter complex, a higher fistulous communication, sacral anomalies and neural abnormalities. But anatomy was not fateful. Almost one-third of children in the complex group continued to be "good" with regard to bowel function. This is clinically significant as families should be given realistic risk estimates and not be told that they will not be able to be continent. Even if spontaneous function is limited, structured bowel management can help to achieve predictable social continence from uncontrolled soiling. The sacral ratio was the best predictor for the poor bowel outcome. The development of the sacral bones and nerves is an easily accessible indicator of the underlying bony and neural foundation for pelvic floor function. Previous studies have investigated the correlation between sacral parameters and fecal continence, although there is a lack of a complete correlation and no single threshold should be used to replace clinical evaluation **[11]**. In this current model, a ratio < 0.60 was also associated with urinary dysfunction, indicating that sacral development may reflect a greater vulnerability of the neuromuscular system of the pelvis. Poor

bowel and poor urinary outcomes were independently associated with tethered cord. This dual association is biologically plausible as the spinal cord and sacral roots are involved in rectal sensation, control of the sphincter, detrusor function and coordinated emptying. Clinical research has shown that sacral development and spinal status are significant factors in predicting urinary continence and other pelvic functional risk factors **[12]**. The take-home message is that spinal abnormalities should not be considered "incidental" findings; they should be evaluated in conjunction with colorectal and urologic and neurosurgical evaluations when symptoms or functional decline are present. Constipation at 2 years of age was a good predictor of poor bowel function later in childhood. This is a possible early intervention that can be changed. Constipation may cause megarectum, loss of sensation, overflow soiling, painful defecation and resistance to treatment. A child with an anorectal malformation may be able to resolve the issue, but it is better to wait until the child is ready. Modern bowel-management programs focus on early distinction between constipation and true fecal incontinence, then on the proper use of laxatives, enemas and/or antegrade access, as necessary and the use of appropriately titrated laxatives **[13]**. The current results are in favor of proactive management prior to school age. Another independent predictor was postoperative anal stenosis. Obstruction of faecal elimination, faecal stasis, progressive distention of the rectum and secondary soiling can result from stenosis. The association was not as strong as with anatomy or sacral factors but is clinically significant. If there is significant stenosis, it can be reduced by careful postoperative examination, proper calibration or dilatation and prompt correction of the stenosis. Anatomical complexity had a significant relationship with urinary dysfunction, which occurred in about one quarter of the cohort. The strongest urinary predictor was associated genitourinary anomalies, highlighting the importance of bladder and urinary tract outcomes being related to congenital anatomy other than the reconstructed anus. This observed relationship is in line with the findings of various studies which indicate that anatomical, sacral and spinal factors can predict urinary continence **[12-15]**. It also advocates for long term urological follow up instead of discharge after a normal early post-operative course. Urinary tract infection that occurred more than once in the first 2 years of life was an independent predictor of poor urinary function later in life. Recurrent infection early in life can be a sign of vesicoureteral reflux, incomplete emptying, high bladder pressure or structural disease of the urinary tract. It can also help to detect children who need a more thorough evaluation of bladder function. If the infection recurs, then evaluation of residual urine, upper tract dilation (when indicated), reflux (when indicated), bowel dysfunction and the possibility of neurogenic bladder should be considered, not repeated antibiotic treatment. The integrated risk analysis can be particularly beneficial in clinical practice. The likelihood of good bowel function and good urinary function was high in children without a major risk factor and was significantly poorer in children with two or more risk factors. This helps to implement a simple follow-up mechanism based on risk. There may be a need for low-risk children to be routinely screened functionally and educated in the family. If a child has one major risk factor, he or she should be monitored more closely. Those at multiple risks should be referred to a coordinated multidisciplinary colorectal-urology pathway early with clear bowel targets, surveillance for infection, assessment of post void residual and urodynamics if clinically indicated. Future studies in the real world should include prospective enrollment of children from the time of reconstruction, standard definitions at specific developmental periods and incorporate the following: anatomy, sacral imaging, spinal status, bowel treatment exposure, urodynamic findings, renal outcomes and patient-reported quality of life. Predictive models need to be validated outside of the system and need to include not only the identification of risk but also the impact of early intervention on trajectory. The results all point towards a change from procedure-centered follow-up to function-centered lifelong care. The most informative predictors were present well before the onset of adolescence, providing a window of opportunity for intervention before the development of chronic soiling, constipation, infection or bladder dysfunction. Theeuwes *et al.* (2026) examined bowel and bladder outcomes in children with anorectal malformations and sacral agenesis, highlighting the contribution of associated sacral anatomy to functional morbidity **[16]**. Ahmad *et al.* (2025) likewise emphasized multidisciplinary long-term management of gastrointestinal and urinary sequelae **[17]**. These reports are consistent with the risk-stratified follow-up proposed here, but their populations and outcome definitions are not interchangeable with those of the present modeled PSARP cohort.

Conclusion:

The long-term bowel and urinary function following posterior sagittal anorectoplasty was highly variable and dependent on the complexity of the malformation and other factors associated with the sacral, spinal, genitourinary and early post-operative periods. Children with a low sacral ratio, a tethered cord, severe early constipation, anal stenosis, genitourinary anomalies or recurrent early febrile urinary tract infection were at increased risk. There is potential for earlier rehabilitation, better family counseling and avoidance of unnecessary long-term morbidity through structured risk based follow-up for colorectal and urological care.

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