# Gravity-assisted drainage imaging in the assessment of pediatric hydronephrosis

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## Abstract

**Introduction:** As early detection of hydronephrosis increases, we require better methods of distinguishing between pediatric patients who require pyeloplasty vs. those with transient obstruction. Gravity-assisted drainage (GAD) as part of a standardized diuretic renography protocol has been suggested as a simple and safe method to differentiate patients.
**Methods:** Renal scans of 89 subjects with 121 hydronephrotic renal units between January 2004 and March 2007 were identified and analyzed.
**Results:** Of all renal units, 65% showed obstruction. GAD maneuver resulted in significant residual tracer drainage in eight renal units, moderate drainage in 12 renal units, and some improvement in 40 units after the GAD maneuver. Of the eight renal units with significant residual tracer drainage, only two proceeded to pyeloplasty. After pyeloplasty, nine children had improved time to half maximum ($T^{1/2}$ Max) and 13 were unchanged.
**Conclusions:** Our study was limited due to its retrospective design and descriptive analyses, but includes a sufficient number of subjects to conclude that GAD as part of a diuretic renography protocol is an effective and simple technique that can help prevent unnecessary surgical procedures in pediatric patients.

## Introduction

With the adoption of antenatal sonography as a routine screening tool, early detection of hydronephrosis has increased.[1,2] When pelvicaliceal system distention is detected, it often leads to further investigation, including diuretic renography. This imaging modality can help identify patients with ureteropelvic junction obstruction (UPJO) and compromised renal function.[3] Early identification of significant UPJO allows for interventions such as pyeloplasty, which can improve kidney drainage and preserve renal function. Those patients with mechanical obstruction suggestive of UPJO on diuretic renography, significant flank pain, or recurrent urinary tract infections are often considered for pyeloplasty, particularly if there is evidence of decline in differential renal function (DRF) on serial diuretic renal scans.[4] Selecting which patients will benefit from pyeloplasty remains a challenge. There is a lack of standardized protocols for both performing and interpreting diuretic renography. Additionally, many centres image patients in the supine position, which may underestimate drainage compared to the upright position, where the effects of gravity can help facilitate drainage (Fig. 1).[5]

## Methods

The present study was approved by the Research Ethics Board at the IWK Health Centre. Ultrasonography was used to identify the presence of hydronephrosis, after which patients were referred for diuretic renal scans. Diuretic renography involves serial imaging of an injected radioactive tracer as it is filtered or secreted within the kidney through to its excretion in urine. Each child received simultaneous intravenous injection of 5 MBq/kg $Tc^{99m}$ mercapto-acetyl-triglycine (MAG-3) and 1 mg/kg (to a maximum of 40 mg) of furosemide. After radiotracer injection, the patient is placed supine over a gamma camera that takes serial images of the radiotracer transit through the kidney, typically over a period of 20–30 minutes. Computer analysis of the uptake and excretion phases is performed to quantitate differential renal function (right vs. left), time to half maximum tracer activity ($T^{1/2}$ max), as well as the degree and significance of any obstruction. $T^{1/2}$ max of less than 10 minutes indicates the absence of obstruction, while a $T^{1/2}$ max of greater than 20 minutes is compatible with obstruction. A $T^{1/2}$ max between 10 and 20 minutes is considered equivocal.[6] A gravity-assisted drainage (GAD) image was then performed at the end of the renal scan. The GAD image is a single, static image obtained after positioning the child in the upright position for five minutes to promote additional drain-

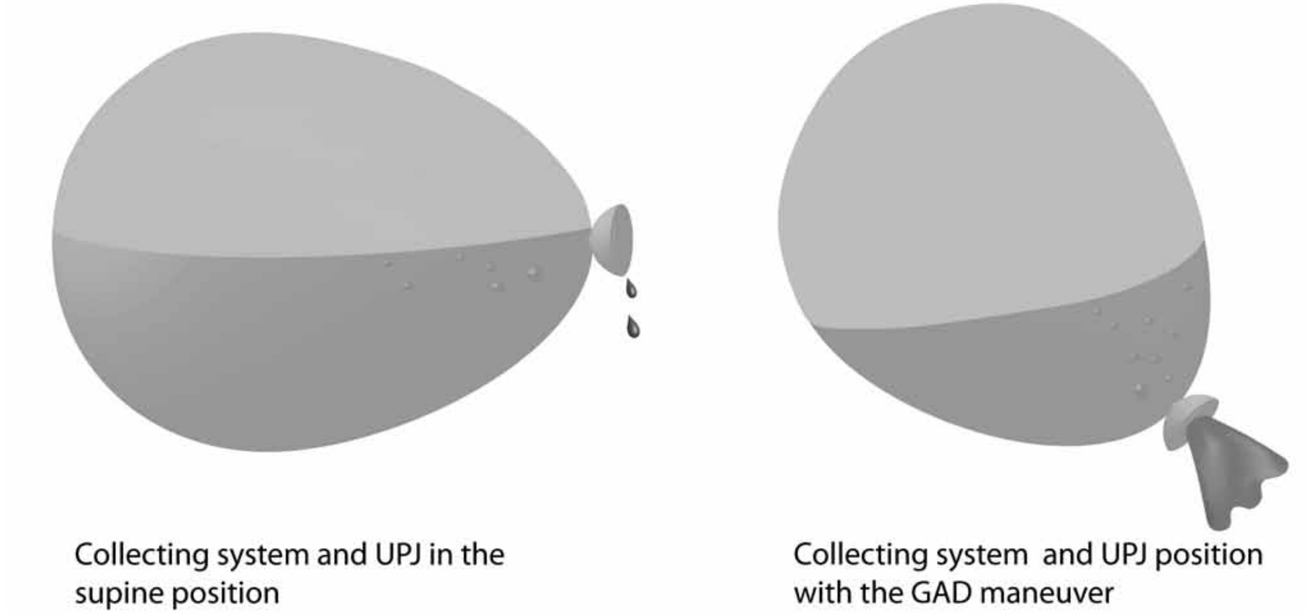


***Fig. 1.*** Balloon analogy for describing gravity-assisted drainage. UPJ: ureteropelvic junction.

age of tracer from the collecting system. Percent drainage was calculated after the GAD maneuver. Residual tracer drainage >50% was considered significant, while 30–49% was considered moderate, 10–29% showing some improvement, and <10% was classified as no change. Followup was limited to the first postoperative renal scan, typically performed 3–6 months post-pyeloplasty.

Dismembered pyeloplasty was offered to patients who had an obstructed renal unit and a low GAD score on serial imaging, an obstructed renal unit with deterioration in renal function on serial imaging, or were experiencing symptoms or complications (e.g., flank pain or pyelonephritis) related to their UPJO. For patients who underwent pyeloplasty, percent change in dynamic renal function was assessed through comparison of preoperative and most recent postoperative diuretic renography, including $T^{1/2}$ max calculations and quantification of GAD.

Our study included children who were referred for GAD renography between January 2004 and March 2007. Scans were excluded from analysis if they showed duplicated collecting systems, ectopic ureter or ureterocele (n= 25), megaureter or ureterovesical junction obstruction (n=21), vesicoureteral reflux (n= 19), incomplete studies (n=7), presence of horseshoe kidney (n=4), non-functioning renal unit (n=6), or posterior urethral valves (n=3). Descriptive statistics were used in this observational study.

## Results

Renal scans of 174 consecutive children with sonographically detected hydronephrosis who were referred for GAD renography between January 2004 and March 2007 were reviewed; 85 scans were excluded from analysis, as per exclusion criteria. Data from 18 of the remaining renal scans were missing complete $T^{1/2}$ max data and were excluded from analyses. After exclusion, 89 subjects with 121 hydronephrotic renal units remained for analysis (Fig. 2). Among the scans remaining, 76 were left-sided, 21 were right-sided,

**Table 1. Descriptive statistics by renal unit**

| | | Baseline$T^{1/2}$ normal (<10 min) | Baseline $T^{1/2}$ equivocal (10–20 min) | Baseline$T^{1/2}$ abnormal (>20 min) | Total |
|---|---|---|---|---|---|
| | Mean time | 8.47 min | 16.39 min | Not reached | 14.10 |
| Sex | Female | 4 | 1 | 21 | 26 |
| | Male | 13 | 24 | 58 | 95 |
| Pyelopasty | Yes | 0 | 4 | 22 | 26 |
| | No | 17 | 21 | 57 | 95 |
| Laterality | Left | 8 | 15 | 53 | 76 |
| | Right | 1 | 4 | 16 | 21 |
| | Bilateral | 8 | 6 | 10 | 24 |

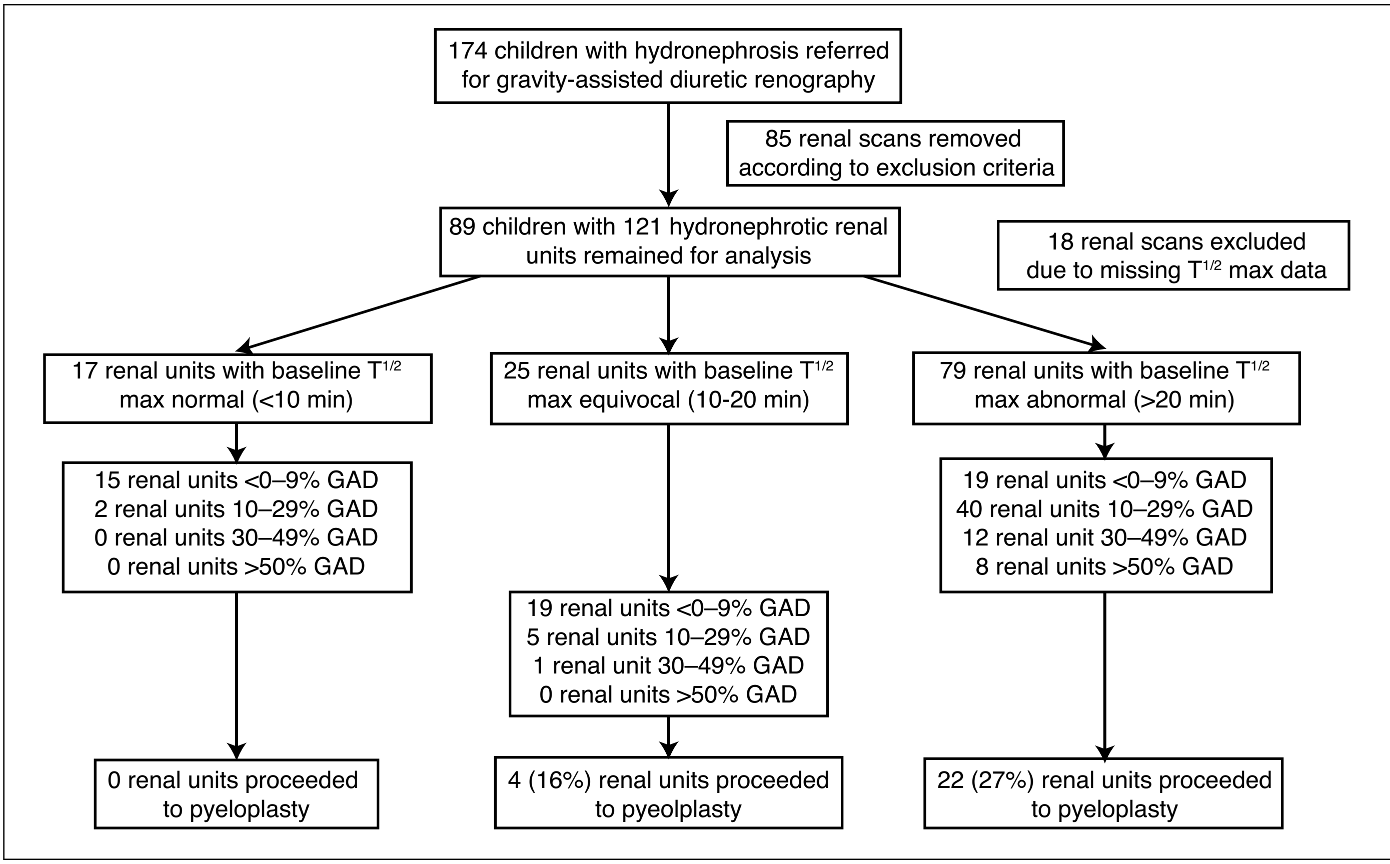


***Fig. 2.*** Summary of patient management. GAD: gravity-assisted diuretic renography.

and 12 showed bilateral hydronephrosis (for 24 renal units), corresponding to a 2.7:1 ratio of left- to right-sided obstruction. Twenty-two pyeloplasty procedures were performed in our analyses (Table 1).

Of all renal units, 79 (65%) showed renographic evidence of obstruction ($T^{1/2}$ >20 minutes). The average T $^{½}$ max in normal unobstructed renal units ($T^{1/2}$ <10 minutes) was 8.56 minutes. For equivocal renal units ($T^{1/2}$ max 10–20 minutes), the average time to drainage was 15.60 minutes. For the 79 obstructed renal units ($T^{1/2}$ max >20 minutes) the GAD maneuver resulted in significant (>50%) residual tracer drainage in eight renal units (10%), moderate (30–49%) drainage in 12 renal units (15%), some improvement (10–29% change) in 40 units (51%), and no improvement (<10%) in 19 units (24%) (Fig. 2). Of the eight renal units with a significant residual tracer drainage, only two proceeded to pyeloplasty, as they had multiple episodes of hydronephrosis that necessitated eventual operative management.

Pre- and post-pyeloplasty data on GAD percent change for obstructed renal units ($T^{1/2}$ max >20) was analyzed for all 22 individuals (Fig. 2). Post-pyeloplasty $T^{1/2}$ max was normal in two individuals, equivocal in eight individuals and unchanged ($T^{1/2}$ max >20) in 12 individuals. Following the pyeloplasty procedure, the GAD maneuver resulted in significant (>50%) residual tracer drainage in no renal units (0%), moderate (30–49%) drainage in three renal units (14%), some improvement (10–29% change) in six units (27%), and no improvement in 13 units (59%) (Fig. 3).

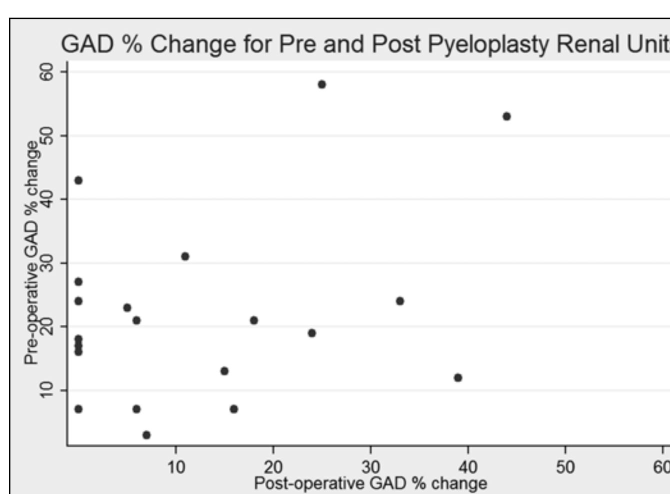


***Fig. 3.*** Pre- vs post-pyeloplasty gravity-assisted drainage change in obstructed ($T^{1/2}$ max >20 min) renal units.

## Discussion

GAD as part of a diuretic renography protocol is an effective, simple procedure that may provide additional diagnostic information in pediatric patients with hydronephrosis being considered for surgical management. In our retrospective study, eight renal units (10%) showed a significant (>50%) improvement in drainage with the GAD maneuver, while 12 (15%) showed moderate improvement (30–49%) in residual tracer activity following this simple preoperative maneuver. This suggests that 25% of these "obstructed" renal units were not truly obstructed, but simply required gravity to assist drainage of residual urine from an unobstructed, capacious collecting system. We demonstrated that this simple maneuver during diuretic renography obviated the need for pyeloplasty in six of eight "obstructed" renal units.

The GAD procedure has been previously reported[4,7] and has been recommended by at least one clinical practice guideline,[8] although it has not become standard of practice at all institutions. This procedure is easy to implement, carries no risk to the patient, and is demonstrated to have acceptable sensitivity and specificity to differentiate children who truly have obstructed renal units from those who do not.[4] Our results are also consistent with other reports on the advantage of the GAD maneuver for improving the diagnostic accuracy of diuretic renography. Amarante et al (2003) performed a retrospective review of 24 patients that showed 43% of kidneys were classified as adequately drained on a post-void GAD image, as compared to 13% in the pre-void image.[9]

Other studies have also demonstrated the need for diagnostic accuracy using diuretic renography before undertaking pyeloplasty. Koff et al (2005) demonstrated that obstructive appearance on diuretic renography was ultimately determined to be non-obstructed in 40% of renal units, and that this finding was particularly evident in children under the age of two years.[10] They highlight the need for caution in the use of diuretic renography to determine if surgical management is required.[10] Yang et al (2010) showed that an early observation period is beneficial before undertaking pyeloplasty, especially given that many subjects with asymptomatic Grade 1 and 2 hydronephrosis have benign conditions that do not often improve with intervention. They demonstrated some benefit from pyeloplasty in individuals with more severe (≥ Grade 3 hydronephrosis) obstruction,[11] although the literature has been mixed in this area.[12,13] Our series showed overall little benefit of pyeloplasty, with return to normal function in only two renal units. Helmy et al (2012) showed improvement in hydronephrosis on all subjects who underwent pyeloplasty, although 65% continued to show persistent obstruction on diuretic renography.[14] A systematic review in this area by Castagnetti et al (2008) concluded that symptomatic patients diagnosed postnatally, and those with moderate rather than severely compromised preoperative function seem to have the greatest chance of functional improvement after surgery.[15]

There are several limitations to our study. Our data were obtained retrospectively, which limited the type of information we could collect and the types of statistical analyses we could perform. Our followup period was also limited to the first postoperative renal scan in patients who underwent a pyeloplasty. Future studies should follow patients longitudinally to determine long-term renal function. It is possible that the small number of participants has biased our observations, although our results are similar to trends noted in previous studies.[4,7] Since this is an observational study, we did not perform calculations to determine appropriate sample size, but felt that our analysis of these 174 scans before exclusion criteria represented an appropriate and practical sample for our analyses.

## Conclusion

GAD imaging during diuretic renography is safe and effective, and provides valuable, additional diagnostic information in pediatric patients with hydronephrosis and possible UPJO. It has become the standard practice at our institution.

**Competing interests:** The authors declare no competing financial or personal interests.

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This paper has been peer-reviewed.

### References

1. Tripp BM, Homsy YL. Neonatal hydronephrosis—the controversy and the management. *Pediatr Nephrol Berl Ger* 1995;9:503-9. http://dx.doi.org/10.1007/BF00866741
2. Nguyen HT, Herndon CDA, Cooper C, et al. The Society for Fetal Urology consensus statement on the evaluation and management of antenatal hydronephrosis. *J Pediatr Urol* 2010;6:212-31. http://dx.doi.org/10.1016/j.jpurol.2010.02.205
3. Belarmino JM, Kogan BA. Management of neonatal hydronephrosis. *Early Hum Dev* 2006;82:9-14. http://dx.doi.org/10.1016/j.earlhumdev.2005.11.004
4. Wong DC, Rossleigh MA, Farnsworth RH. Diuretic renography with the addition of quantitative gravity-assisted drainage in infants and children. J *Nucl Med Off Publ Soc Nucl Med* 2000;41:1030-6.
5. Houben CH, Wischermann A, Börner G, et al. Outcome analysis of pyeloplasty in infants. *Pediatr Surg Int* 2000;16:189-93. http://dx.doi.org/10.1007/s003830050720
6. Shulkin BL, Mandell GA, Cooper JA, et al. Procedure guideline for diuretic renography in children 3.0. *J Nucl Med Technol* 2008;36:162-8. http://dx.doi.org/10.2967/jnmt.108.056622
7. Rossleigh MA, Leighton DM, Farnsworth RH. Diuresis renography. The need for an additional view after gravity-assisted drainage. *Clin Nucl Med* 1993;18:210-3. http://dx.doi.org/10.1097/00003072-199303000-00005
8. Gordon I, Piepsz A, Sixt R, Auspices of Pediatric Committee of European Association of Nuclear Medicine. Guidelines for standard and diuretic renogram in children. *Eur J Nucl Med Mol Imaging* 2011;38:1175-88. http://dx.doi.org/10.1007/s00259-011-1811-3

9. Amarante J, Anderson PJ, Gordon I. Impaired drainage on diuretic renography using half-time or pelvic excretion efficiency is not a sign of obstruction in children with a prenatal diagnosis of unilateral renal pelvic dilatation. *J Urol* 2003;169:1828-31. http://dx.doi.org/10.1097/01.ju.0000062640.46274.21
10. Koff SA, Binkovitz L, Coley B, et al. Renal pelvis volume during diuresis in children with hydronephrosis: Implications for diagnosing obstruction with diuretic renography. *J Urol* 2005;174:303-7. http://dx.doi.org/10.1097/01.ju.0000161217.47446.0b
11. Yang Y, Hou Y, Niu ZB, et al. Long-term followup and management of prenatally detected, isolated hydronephrosis. *J Pediatr Surg* 2010;45:1701-6. http://dx.doi.org/10.1016/j.jpedsurg.2010.03.030
12. Gordon I. Diuretic renography in infants with prenatal unilateral hydronephrosis: An explanation for the controversy about poor drainage. *BJU Int* 2001;87:551-5. http://dx.doi.org/10.1046/j.1464-410X.2001.00081.x
13. Duong HP, Piepsz A, Collier F, et al. Predicting the clinical outcome of antenatally detected unilateral pelvi-ureteric junction stenosis. *Urology* 2013;82:691-6. http://dx.doi.org/10.1016/j.urology.2013.03.041
14. Helmy TE, Sarhan OM, Sharaf DE. Critical analysis of outcome after open dismembered pyeloplasty in ectopic pelvic kidneys in a pediatric cohort. *Urology* 2012;1357-60. http://dx.doi.org/10.1016/j.urology.2012.07.057
15. Castagnetti M, Novara G, Beniamin F, et al. Scintigraphic renal function after unilateral pyeloplasty in children: A systematic review. *BJU Int* 2008;102:862-8. http://dx.doi.org/10.1111/j.1464-410X.2008.07597.x

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