Stone Volume is a Better Predictor of Spontaneous Stone Passage

Seth K. Bechis, MD, MS
Associate Professor of Urology

Department of Urology
UC San Diego Health
sbechis@health.ucsd.edu

https://www.canpharm.com/blog/how-long-kidney-stone-to-pass

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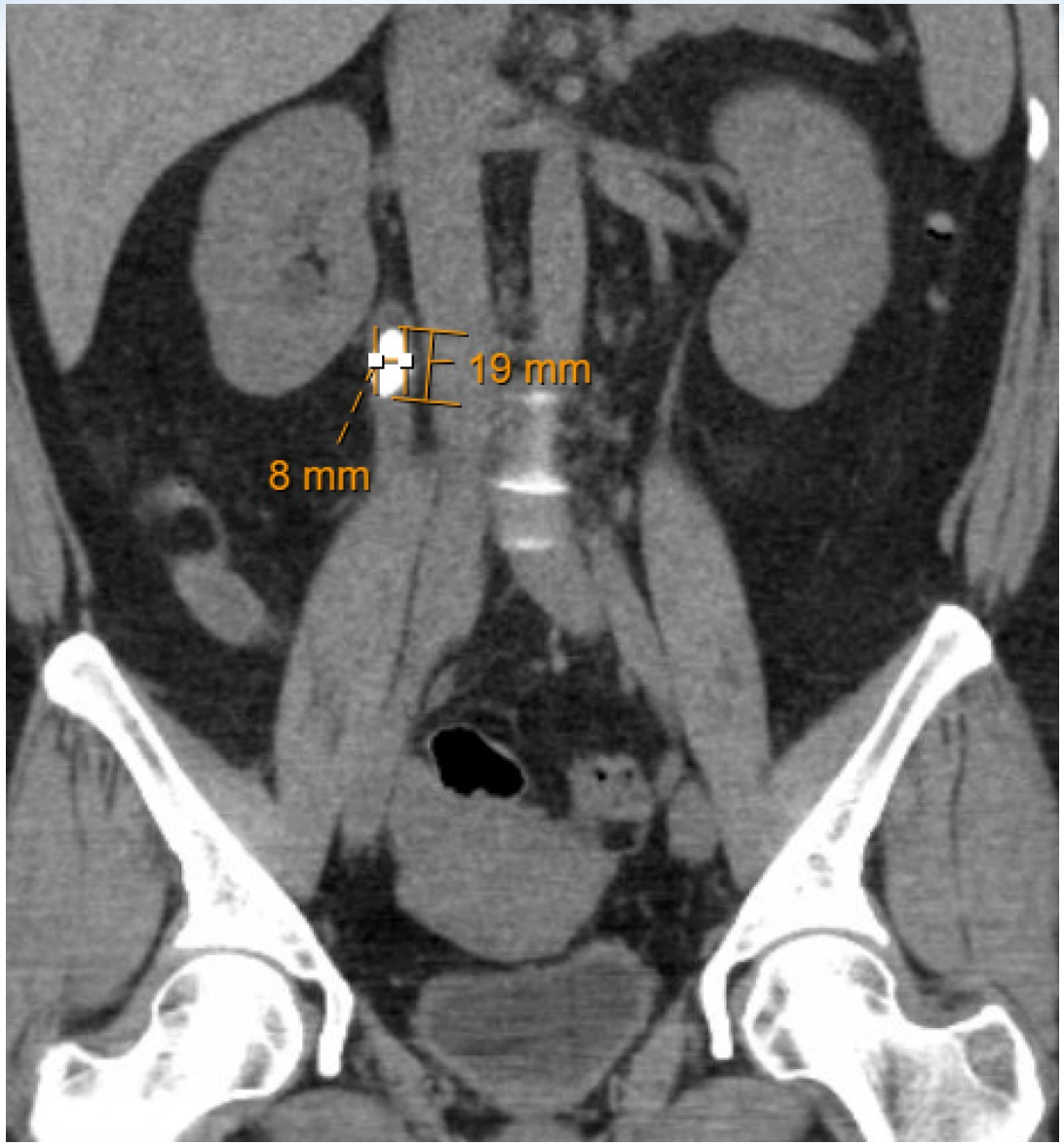
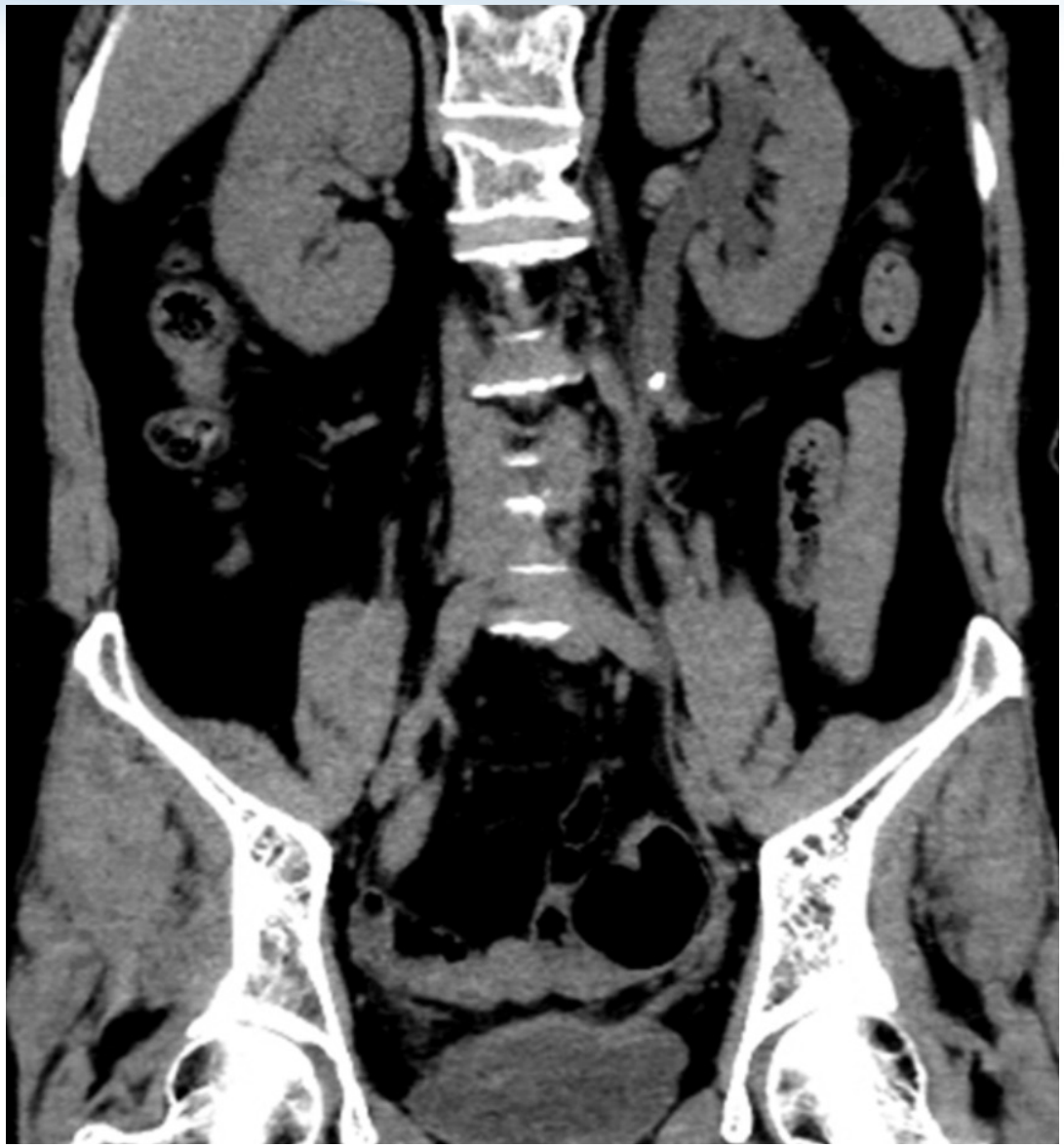
Disclosures

- Consultant
  - Ambu
  - Auris
  - Boston Scientific
  - BD
  - Calyxo
  - Dornier
  - Olympus
- Speaker
  - Cook Medical
  - Karl Storz Endoscopy

Ureteral stone size is important for guiding management



19mm or 8mm



3mm

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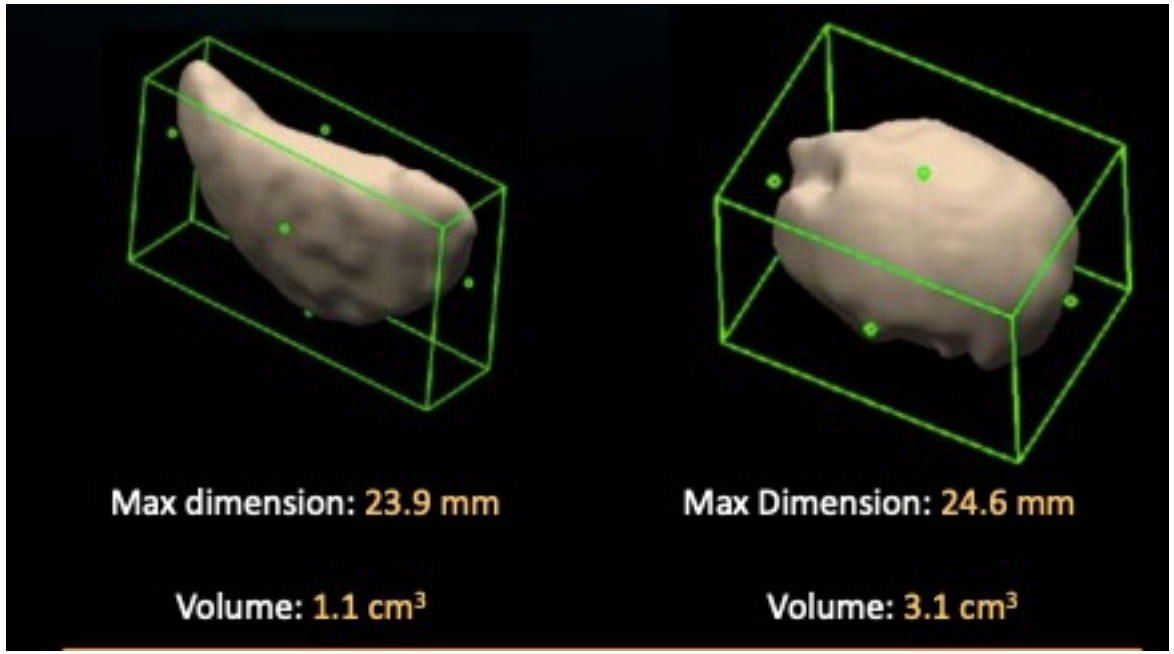
Ureteral stone size is important for guiding management

- Predicting spontaneous passage depends on stone size
- Stone size can also aid in surgical planning
- Current guidelines suggest using linear dimension (LD) as a surrogate for stone burden
  - Radiologist variability in reading CTs (depends on which view is used)



- BUT stone volume can vary despite similar linear size

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Same linear dimension, different volumes

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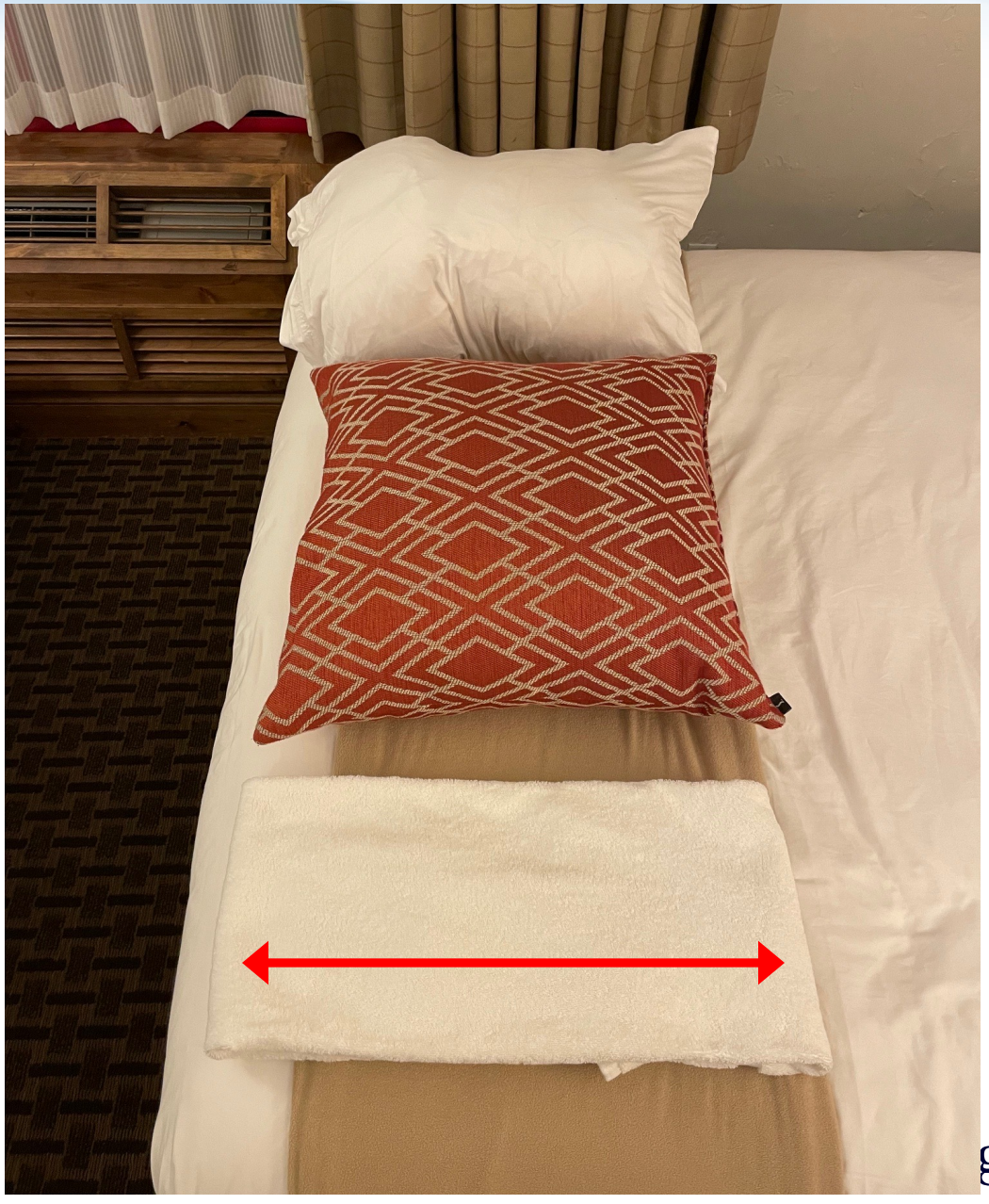
Same linear dimension, different volumes



What is the best way to measure stone burden?

- Formula-derived stone volume better than using maximal stone diameter to predict spontaneous passage
- Automated volume measurement was equally accurate but more precise compared to radiologists' variation
- Ellipsoid formula and automated algorithm are both effective to measure SV and correlate with stone passage

J Endourol. 2016 Jan;30(1):32-6. doi: 10.1089/end.2015.0481. Epub 2015 Sep 9.

CT-Based Determination of Ureteral Stone Volume: A Predictor of Spontaneous Passage

Orhan Ünal Zorba [1], Sabri Ogullar [2], Selim Yazar [1], Gorkem Akca [1]

Eur Radiol. 2018 Jun;28(6):2474-2483. doi: 10.1007/s00330-017-5242-9. Epub 2018 Jan 24.

Prediction of spontaneous ureteral stone passage: Automated 3D-measurements perform equal to radiologists, and linear measurements equal to volumetric

Johan Jendeberg [1], Håkan Geijer [2], Muhammed Alshamari [2], Mats Lidén [2]

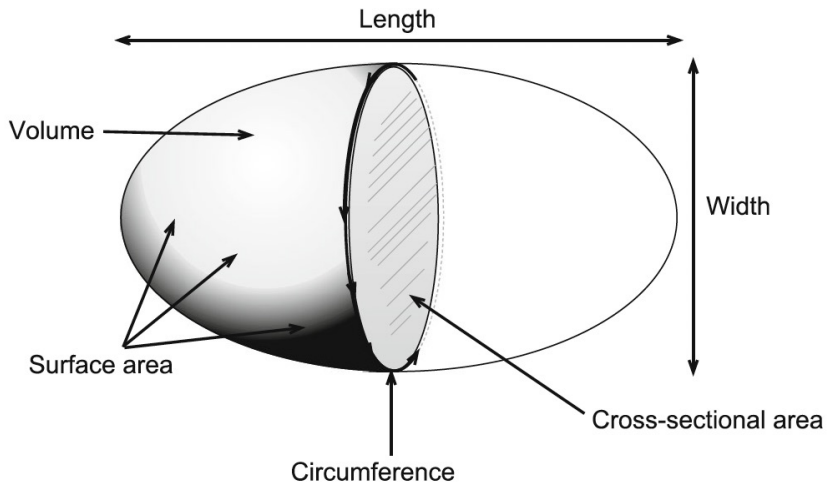
Can Urol Assoc J. 2021 Mar;15(3):E144-E147. doi: 10.5489/cuaj.6491.

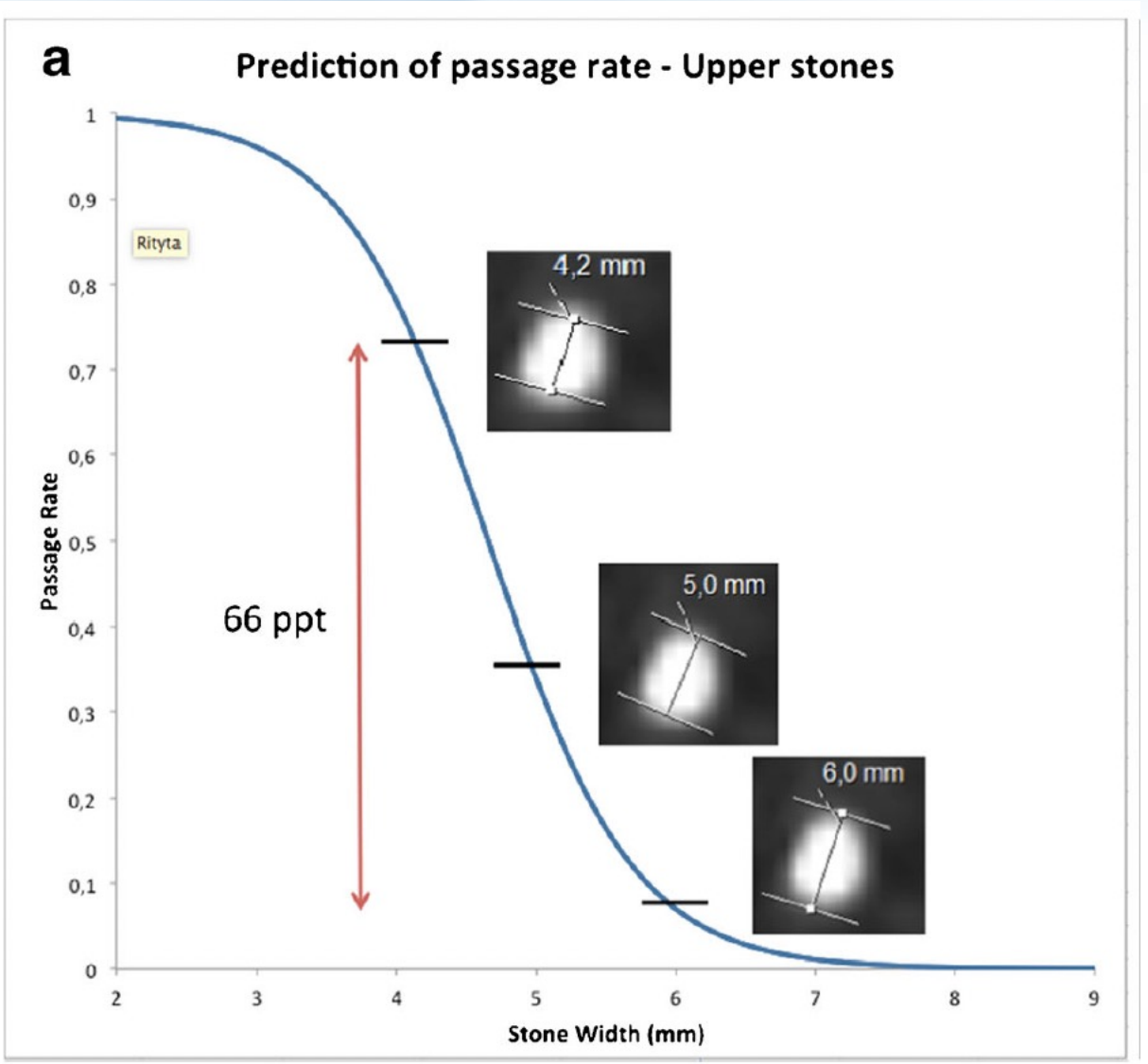
Utility of stone volume estimated by software algorithm in predicting success of medical expulsive therapy

Rajat Jain [1], Sara Maskal [2], Jason Milk [3], Leonard Kahn [4], Donald Fedrigon 3rd [2], Sri Sivalingam [5]

Radiologists differ in their stone measurements

- Reader variations can significantly affect estimated probability for spontaneous passage
- Automated measurement may solve this problem





Jendeberg J et al. Eur Radiology 28;2018.

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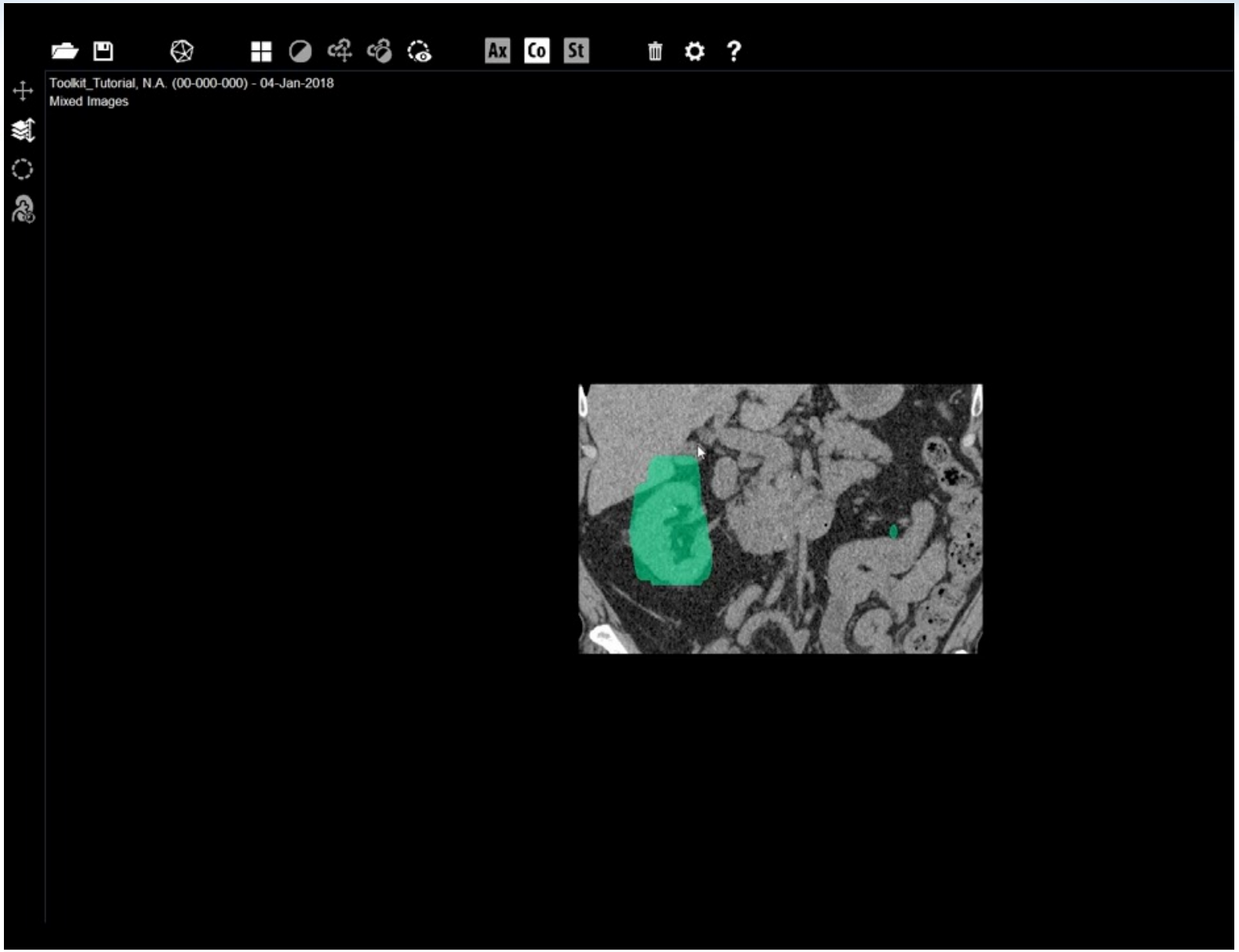
qSAS automated stone volume assessment



- Quantitative Stone Analysis Software (qSAS) created by Mayo Clinic
- Semiautomated software generates standardized reports on stone diameter, location, and volume
- Adaptive threshold method enables identification of both pure and mixed stones
- Uses CT scans with 2-3mm cuts

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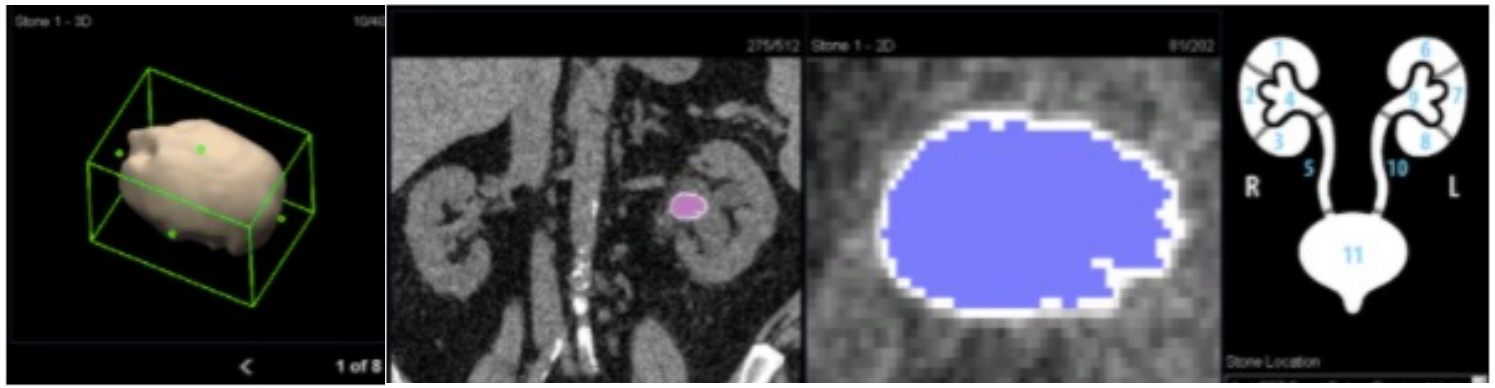
Aim

To evaluate whether program-estimated stone volume (SV) produces better spontaneous passage predictions compared to program-estimated maximal diameter (PD) and manually-measured maximal diameter (MD).

Hypothesis: the comparative advantage of SV would be more pronounced in the context of larger stones.

Design and Methods

- Retrospective: Emergency Department patients, 7/2017-4/2020
- Acute renal colic with single kidney/ureteral stone on non-contrast CT scan
- MD from radiology reports and manually measured
- Quantitative Stone Analysis Software (qSAS) for SV and PD estimation
- Outcome = spontaneous stone passage by 2, 4, 6 weeks (reported or by imaging)



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SP patients had significantly smaller stones

SP – spontaneous passage
SV – stone volume
MD – manual diameter
PD – program diameter

TABLE 1. BASELINE PATIENT AND STONE CHARACTERISTICS

	All patients (n = *172*)	*Spontaneous passage* (n = *71*)	*Procedure* (n = *101*)	p
Age (years)	53 ± 16	51 ± 16	54 ± 15	0.14
Female	66 (38)	23 (32)	43 (42)	0.21
History of stones	73 (43)	24 (34)	49 (49)	0.061
No. of prior stones				
0	99 (57)	47 (66)	52 (51)	0.13
1	31 (18)	10 (14)	21 (21)	
2	15 (9)	7 (10)	8 (8)	
>2	27 (16)	7 (10)	20 (20)	
Side of stones				0.28
Left	94 (55)	35 (49)	59 (58)	0.88
Right	78 (45)	36 (51)	42 (42)	0.12
Radiologist-estimated stone diameter (mm)	6.5 ± 4	4.3 ± 2	8.0 ± 4	**<0.001**
Program-estimated stone maximal diameter (mm)	7.6 ± 4	5.5 ± 2	9.4 ± 4	**<0.001**
SV (mm^3)	200 ± 491	40 ± 40	312 ± 616	**<0.001**
Stone location				
Proximal	89 (52)	11 (15)	78 (77)	**<0.001**
Distal	83 (48)	60 (85)	23 (23)	
Mean HU	453 ± 160	347 ± 103	526 ± 151	**<0.001**
Hydronephrosis				
None	24 (19)	5 (7)	19 (33)	**<0.001**
Mild	79 (61)	52 (77)	27 (44)	
Moderate	25 (20)	11 (16)	14 (23)	
Type of procedure				
SWL			21 (20)	
PCNL			13 (13)	
URS			67 (67)	

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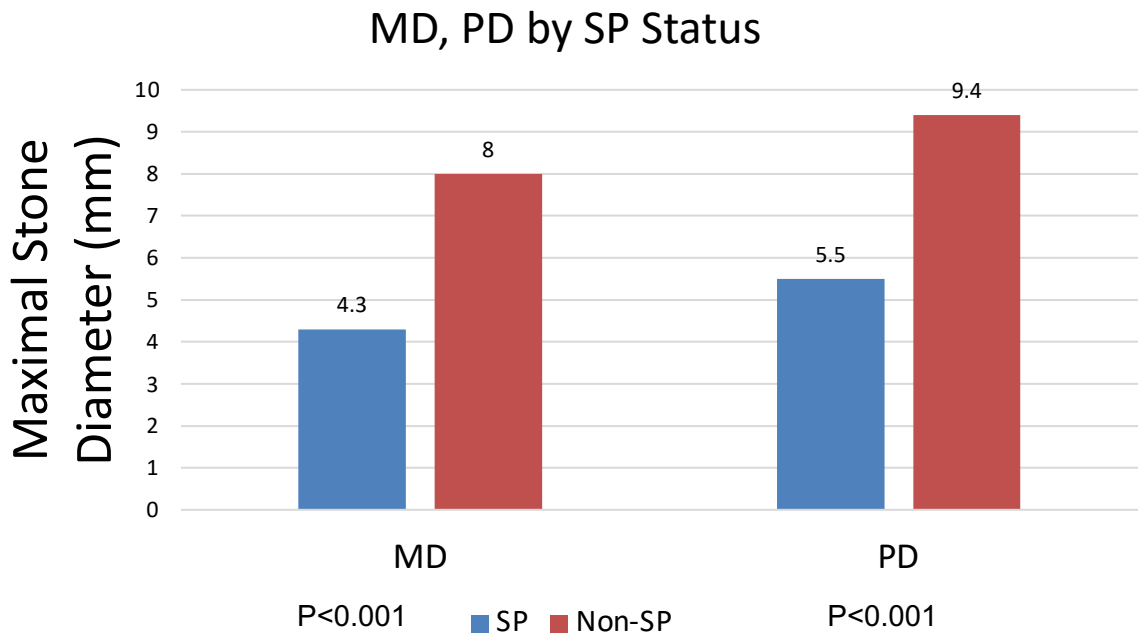
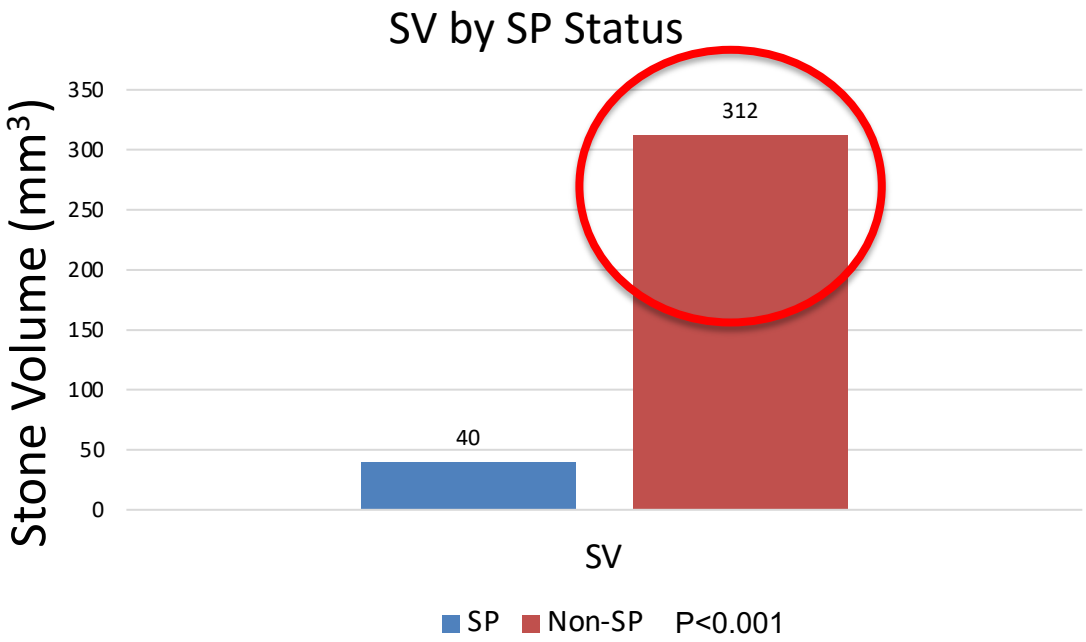
- 172 patients in final cohort, 71 (41%) with SP, 101 (59%) requiring procedure
- No significant difference in age, sex (38%F), stone hx or laterality





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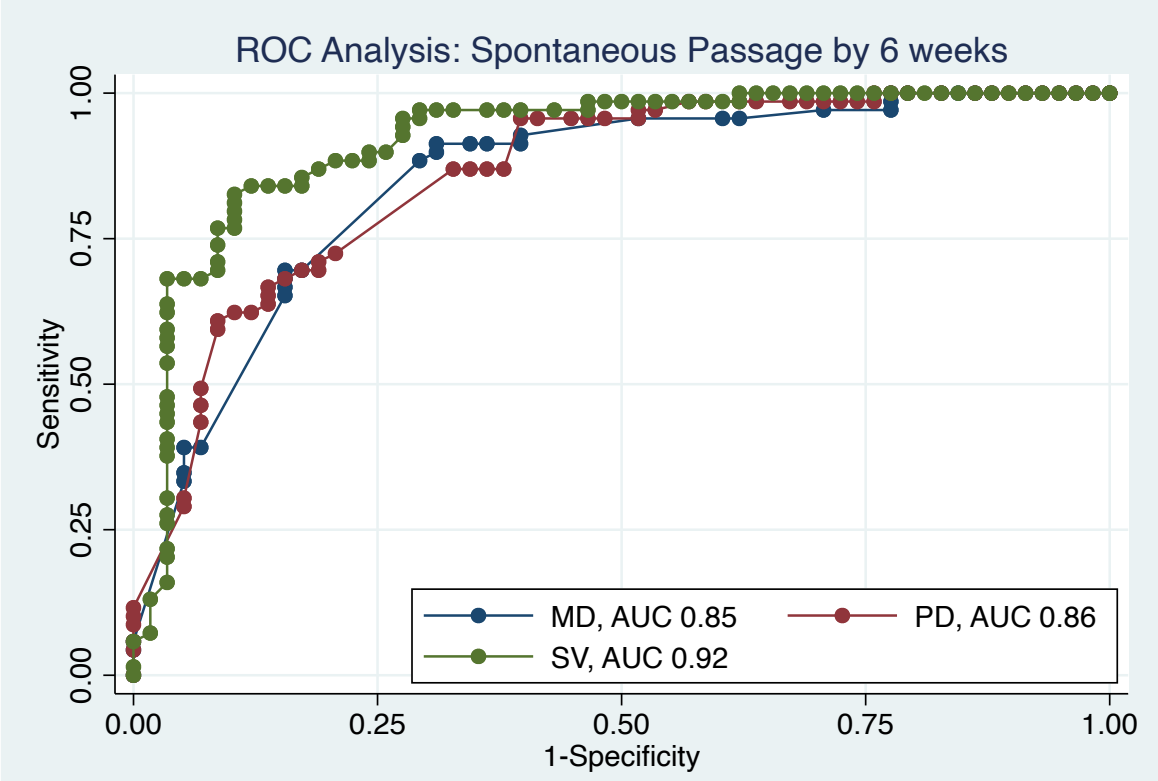
Stone volume better predicts passage by 6 weeks



	AUC	P-Value
Stone Volume	0.92	
Program-measured Diameter	0.86	**0.016** (SV vs PD)
Manually-measured Diameter	0.85	**0.003** (SV vs MD)

SV – stone volume
MD – manual diameter
PD – program diameter

Stone volume better predicts passage of proximal ureteral stones

TABLE 3. AREA UNDER CURVE FOR PREDICTION OF SPONTANEOUS PASSAGE BY STONE LOCATION SUBGROUP

	Prediction of SP by 2 weeks			
	Proximal	p	*Distal*	p
AUC: SV	0.89	*Ref.*	0.82	*Ref.*
AUC: PD	0.78	0.08	0.76	0.10
AUC: MD	0.81	**0.02**	0.82	0.96
	Prediction of SP by 4 weeks			
	Proximal	p	*Distal*	p
AUC: SV	0.93	*Ref.*	0.92	*Ref.*
AUC: PD	0.82	**0.02**	0.87	0.10
AUC: MD	0.85	**0.02**	0.89	0.35
	Prediction of SP by 6 weeks			
	Proximal	p	*Distal*	p
AUC: SV	0.89	*Ref.*	0.93	*Ref.*
AUC: PD	0.81	**0.05**	0.89	0.30
AUC: MD	0.79	**0.02**	0.88	0.29

p-Values use AUC:SV as referent.

SV – stone volume
MD – manual diameter
PD – program diameter

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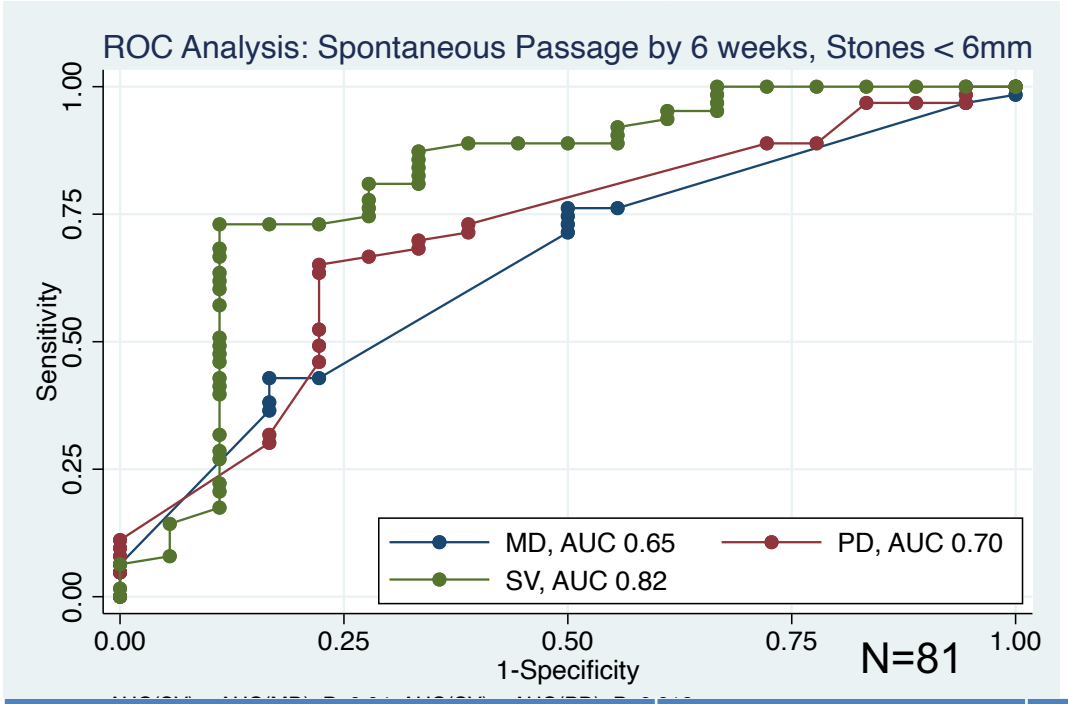
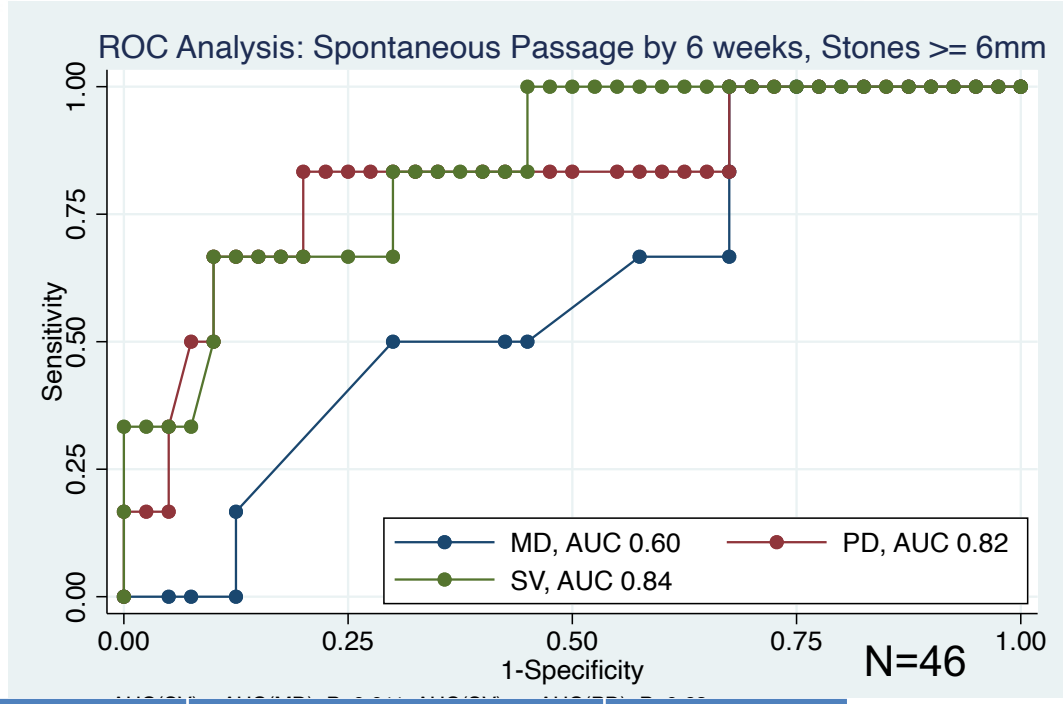
Volume > linear diameter for predicting stone passage





	Stones <6mm	P-value	Stones >=6mm	P-value
AUC Difference (SV vs MD)	0.17	**0.04**	0.24	**0.011**
AUC Difference (SV vs PD)	0.12	**0.016**	0.02	0.63
AUC Difference (PD vs MD)	0.05	>0.05	0.22	**0.043**
	SV > MD, PD		SV, PD > MD	

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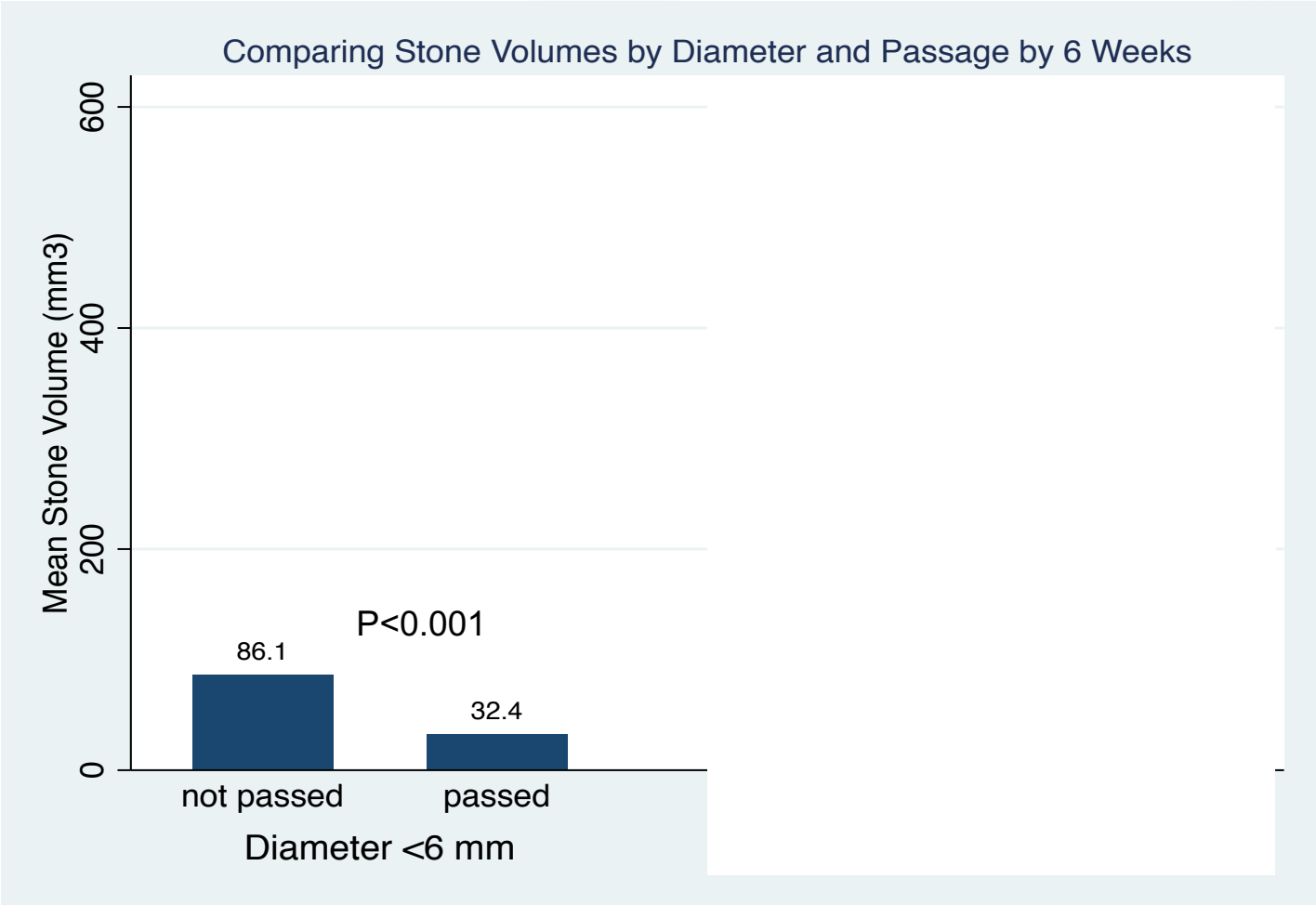
Volume can help further differentiate passed stones

SP – spontaneous passage
SV – stone volume
MD – manual diameter
PD – program diameter



Volume best predicts passed stones for >6mm

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Volume can help further differentiate passed stones

SP – spontaneous passage
SV – stone volume
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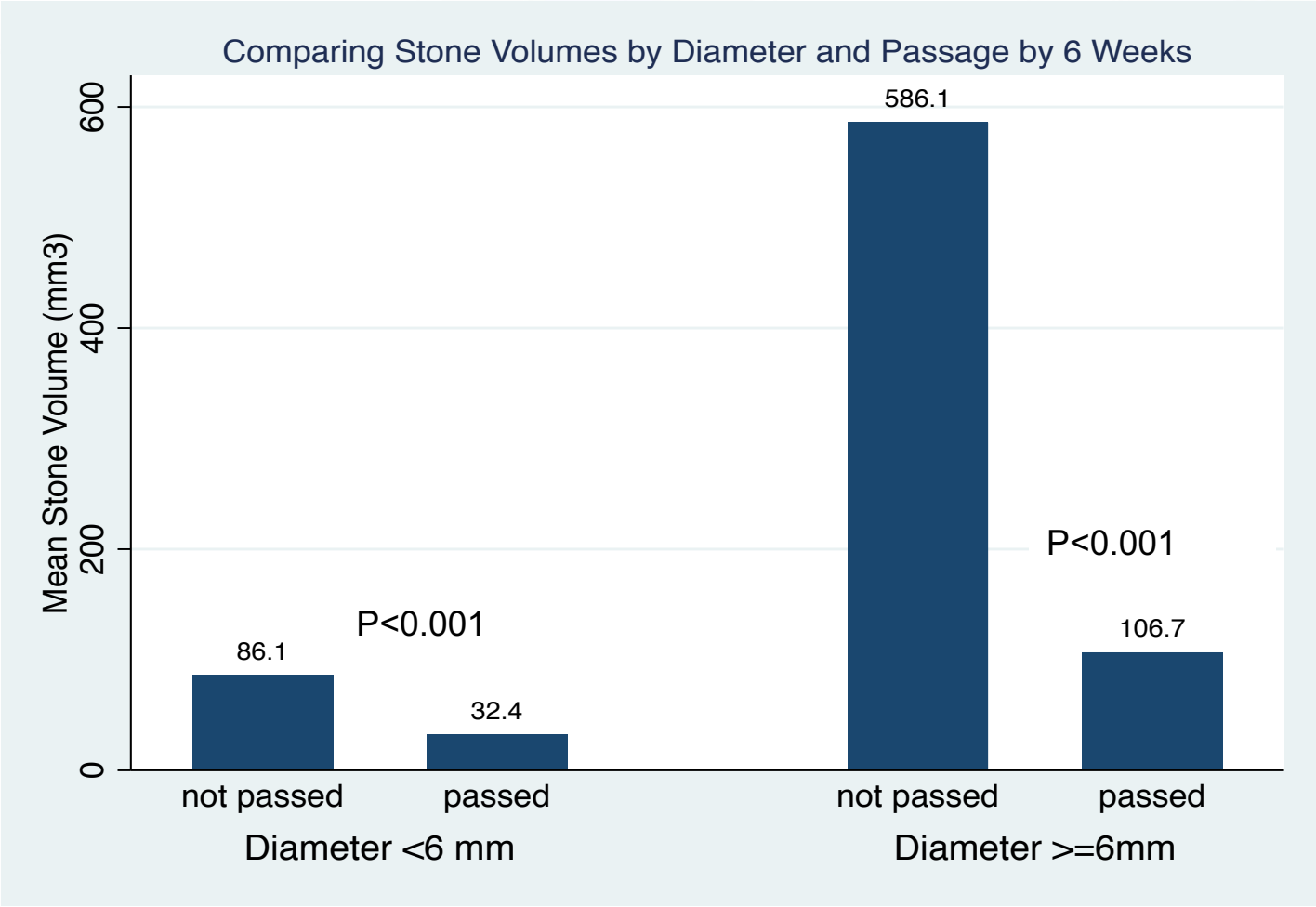
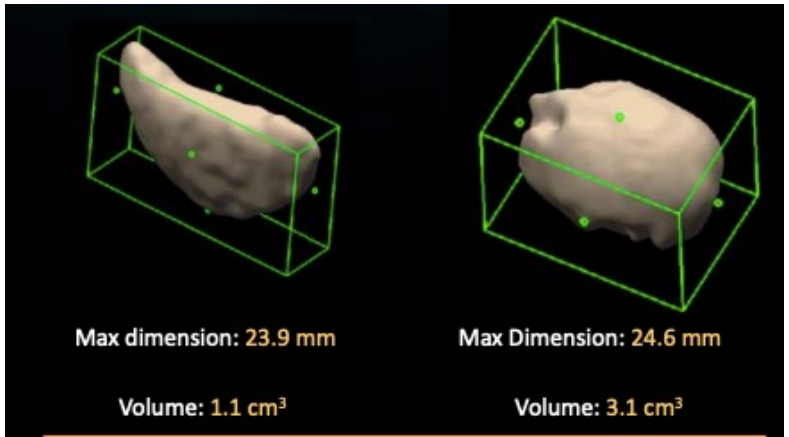


Volume best predicts passed stones for >6mm

May reflect greater variability in shape (ie, football vs sphere)

Need better standardization of radiology reports

- Reports from CT scans performed for urolithoiasis:
  - 78% reported 1-dimensional stone diameter
  - 17% reported 2 dimensions
  - 3% reported 3 dimensions
  - 3% did not mention stone size!



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Conclusions

- Software-calculated stone volume was a better predictor of stone passage than linear measurement (manual or automated) in patients presenting with acute renal colic, especially in the context of larger stones (>6mm)
  - Larger stones tend to have more variability in volume
- Computer-aided stone measurement may be a useful tool to standardize radiology reports
  - Eliminates variability in radiology reads
- Prospective studies are warranted to evaluate the clinical utility of stone volume in guiding patient expectations & treatment decisions.
  - Maybe best suited for larger stones
  - Surgical and outcomes planning for PCNL and URS

References

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Thank you!

Seth Bechis, MD, MS
Associate Professor of Urology
Endourology
Benign Prostatic Diseases

sbechis@health.ucsd.edu

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