(PD35-02) Application of Artificial Intelligence Tool to Identify Patients at High Risk for Symptomatic Kidney Stone Recurrence

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Agenda

- Background snapshot
- Kaiser Permanente (KP) Healthy Stone program
- Healthy Stone program outcomes
- The role of Artificial Intelligence in prediction of kidney stone recurrence
- Performance of AI model in KP kidney stone population
- Application of AI to a larger kidney stone population with focus on patients at highest risk for recurrence
- Conclusion

Background Snapshot

- Kidney Stone is a chronic condition
  - 1 in 11 people in the US will experience kidney stones
  - 50% develop recurrence within 5 to 10 years
- Clinicians should perform additional metabolic testing
  - High-risk or interested first-time stone formers
  - Recurrent stone formers
- Compliance to ordering and completion of the AUA recommended preventive kidney stone studies remains a significant challenge

Healthy Stone Program – Methodology and Results

2013 Kaiser Permanente, South Bay Medical Center pilot

High Risk Patients* for kidney stone recurrence were followed by nurse case manager

Patients contacted at least once by e-mail or phone call if the test was not completed.

Office, operating room and Emergency Room encounters were measured for both high and low risk subgroups

Compared encounter outcomes before and after program implementation

Compliance to ordering metabolic evaluations increased 17% to 35%

Compliance to study completion by patients improved <10% to 82%

Reductions in office visit, surgical procedure and Emergency Department encounters

- A retrospective review of electronic medical records between January 2009 to October 2017 identified 4,029 kidney stone patients with 3 year follow up data.
- Of this group, 873 patients were identified to be at high risk for kidney stone recurrence

*High risk for stone recurrence is defined as stone at young age <30, bilateral stones, multiple stones, stones over 2cm, recurrent stones, and malabsorptive gastrointestinal disorders

Healthy Stone Pilot- Results

Frequency of patient encounters over a 9 year period (2009-2017) for high and low risk patients

Encounters (visits per patient)	**Low Risk (N=3156)**	**High Risk (N=873)**
Office visits	0.87	2.10
Surgical procedures	0.03	0.17
Emergency Department visits	0.08	0.21

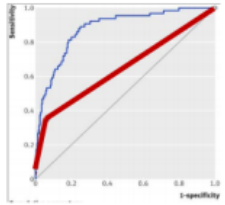
Healthy Stone Pilot - Results

Patient encounters within the high risk subgroup before and after the program implementation				
Encounters (Visits per patient)	Pre-intervention (n=361)	Post-intervention (n=512)	% Change	P value
Office	2.91	1.5	48.50%	<0.0001
Surgical Procedures	0.21	0.13	38.10%	0.0016
Emergency Department	0.27	0.16	40.70%	0.0001

Next steps: Machine Learning and Artificial Intelligence

Machine learning (ML) allows computers to automatically learn how to perform tasks from large amounts of data

Factors: 7 ± 2



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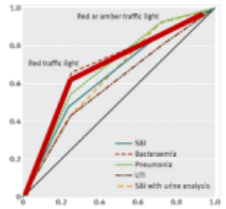

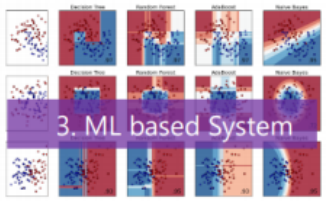

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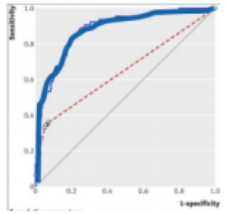


Machine learning models use large, nuanced sets of data to produce accurate, individualized predictions

Application of Machine Learning and Artificial Intelligence

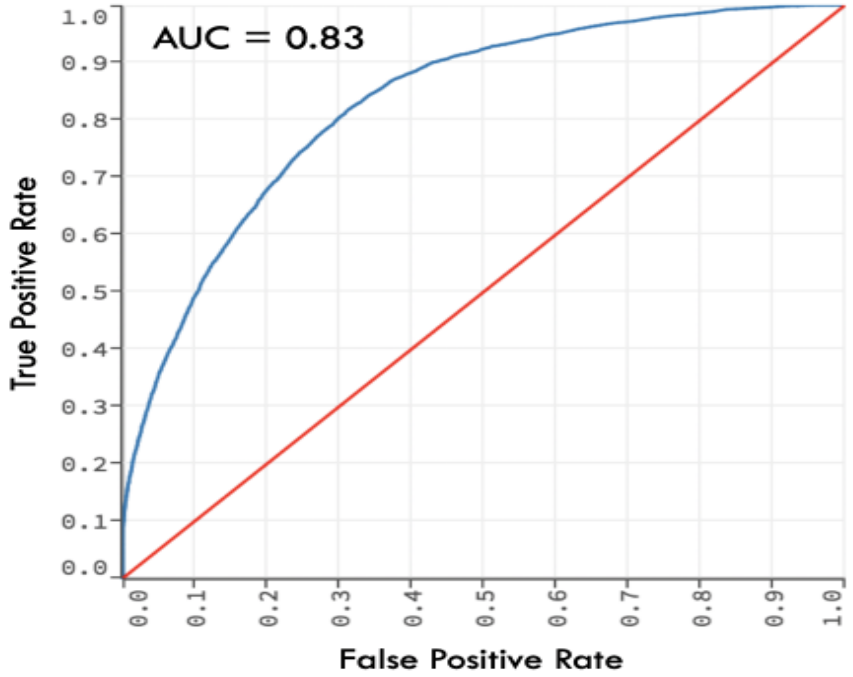
- Developed 2 models to identify symptomatic stone recurrence
  - Any kidney stone episode occurring more than 90 days after initial diagnosis that involved an ED visit, admission, or surgery
- Trained on 516k observations of 108k patients between 2008-2018
- Validated on 1,123 patients between Jan-Jun 2019
- The model considers 655 attributes that were identified through data analysis and clinician input

- Labs
- Office visits
- Admissions
- Procedures
- Demographic

Model 1: Is this patient at risk of symptomatic recurrence?
Model 2: When will this patient have a symptomatic recurrence?

Machine Learning and Artificial Intelligence

- The recurrence risk model identifies high risk patients to enroll in the healthy stones program
- The time to recurrence model prioritizes patients within the high risk group
- Recurrence Risk Model: AUCROC = 0.83
- Time to Recurrence Model: C-statistic: 0.79



Key Features

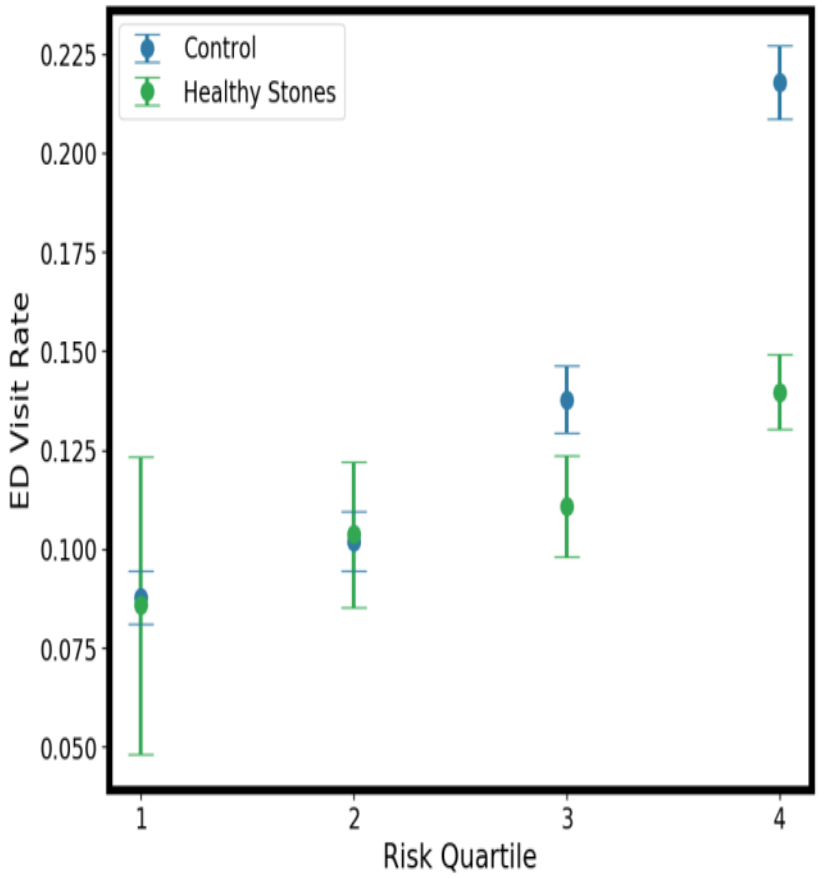
1. Ethnic Group - Non-Hispanic/Non-Latino (-)
2. Previous ED utilization (+)
3. Negative UA HGB in the last year (-)
4. 50-100 UA WBCS/HPF in the last year (+)
5. Irritable Bowel Disease
6. BP (+)
7. UA Specific Gravity in the last year (+)
8. Most recent CL level
9. Most recent K level
10. Age

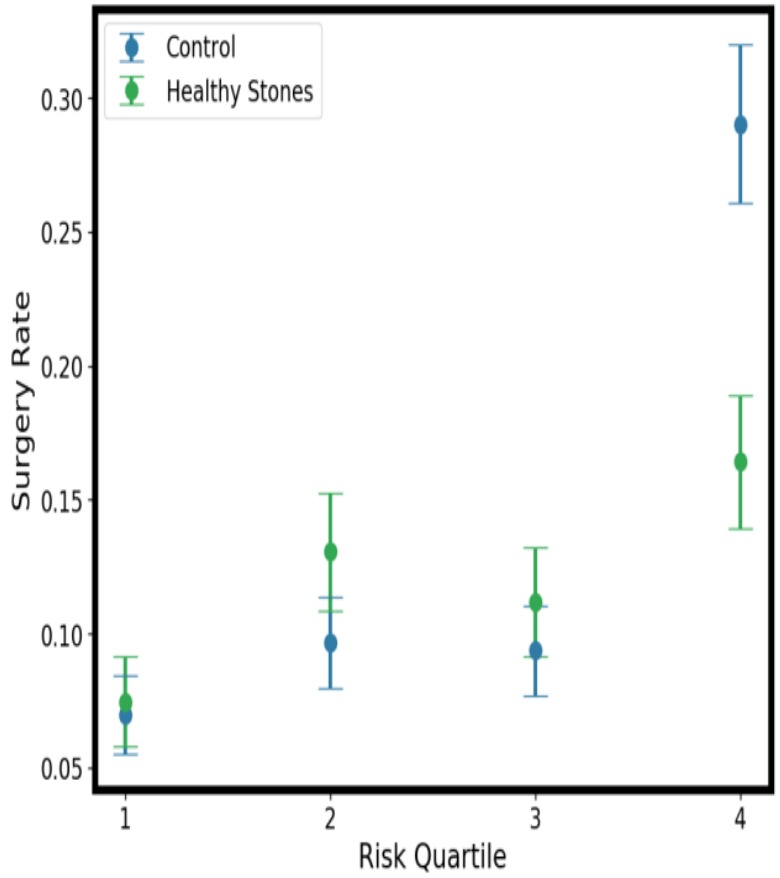
AI Model performance in Kaiser Permanente, South Bay kidney stone population was measured

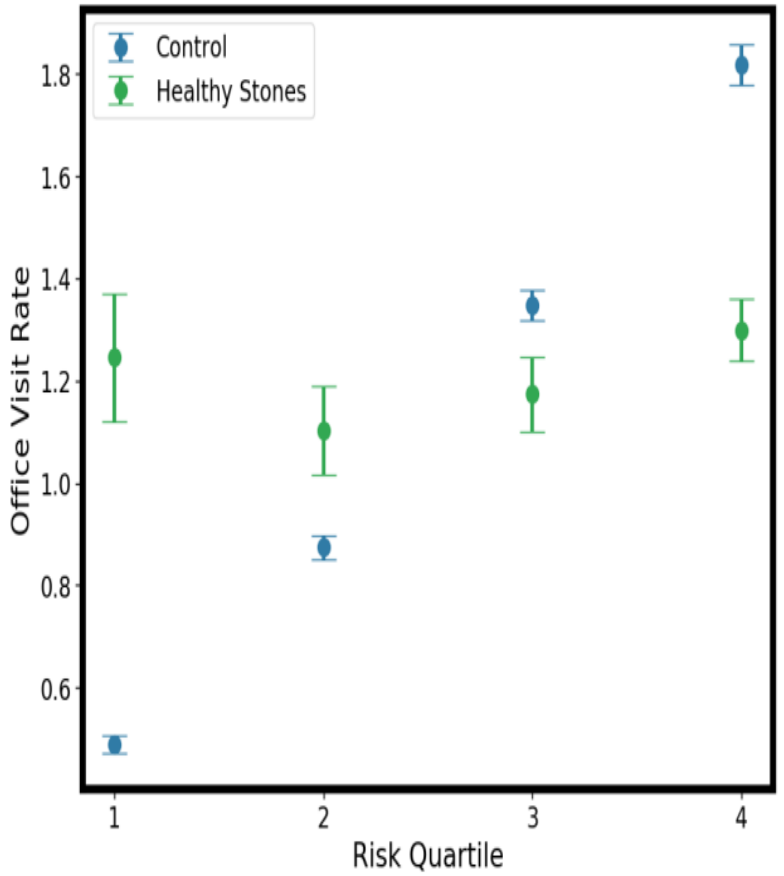
- **Intervention group:** Identified 537 Patients enrolled in the Healthy Stone program with at least three years of follow up data after enrollment in the program
- **Control group:** Identified 1,984 patients who were diagnosed with kidney stones in the same period as the patients in the treatment group, with at least 3 years of follow up data following the diagnosis, and who were not enrolled in the Healthy Stone program.
- Rates of ED visit, surgical procedures and office visit for each of the two cohorts were measured and compared by predicted risk quartile over the 3 year follow up period

ED visit, surgical procedure and office visit rates for each group of patients identified by AI Model predicted risk quartile

Group 4 consists of the top 25% of patients by recurrence risk and group 1 consists of the lowest 25% of patients by recurrence risk







AI model prediction outcomes

- Patients in the low risk score quartiles do not benefit from the Healthy Stone program and the current selection criteria should include risk quartile calculation as the initial screening for the Healthy Stone program.
- Patients who were not selected to be in the Healthy Stone program but are in the high risk quartiles have worse outcome than all other groups. These patients would benefit from the Healthy Stone program.

Next Steps

- Build a comprehensive kidney stone registry
- Roll out program across other Kaiser Permanente facilities in Southern California
  - Narrower patient population (highest risk patients) will be included in the following two groups
    1. Patients referred to the Healthy Stone program after they are pre-screened by the Risk Quartile Model and also qualify for the existing Healthy Stone clinical criteria.
    2. Patients referred to the Healthy Stone program solely based on the output of the Risk Quartile Model.
- Ultimately we want to accurately predict kidney stone recurrence, maximize patient compliance to completion of the ordered studies

Conclusion

- Artificial Intelligence can analyze large and complex data sets and improve clinicians ability to triage patients into low, moderate and high-risk groups.
- This will improve patient counseling and may improve quality of care by implementing preventive measures on high risk patients and reduce metabolic workup, invasive endoscopy and ionizing radiation exposure for low risk kidney stone patients.
- Further follow up is required to determine the long term efficacy of artificial intelligence as a tool to improve the precision of clinical decision making.

Thank You

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