Unenhanced x-ray computed tomography (CT) is the initial imaging modality of choice for patients presenting to the emergency department with acute flank pain. For patients with recurrent stone disease, CT is a critical tool for the quantification of size, number and location of stones, as well as for the assessment of metabolic activity – i.e., stone growth or new stone formation in a year. However, current clinical imaging software and workflow have proven to be inadequate to efficiently and accurately characterize kidney stones, especially for the most complex cases with multiple stones and irregular shapes. As a result, accurate quantification of renal stone burden is rarely included in a radiology report.

The CT Clinical Innovation Center has been developing a semi-automated software system (qSAS) that is able to provide a standardized report of urinary stones in reproducible metrics in order to support radiologists, clinicians, and researchers. qSAS generates fully standardized stone reports in less than 5 minutes per case. The only user interaction required is a coarse delineation of the kidneys, following which the software automatically identifies any renal stone, properly excluding any hardware in the kidneys such as stents and nephrostomy tubes. A retrospective clinical trial on 57 patients undergoing dual-energy CT in a preoperative setting indicated a positive clinical impact of using qSAS in 17/349 stones (5%). That included better stone characterization, especially for complex large stones, as well as improved separation of adjacent stones. qSAS is currently used for all kidney stones CT imaging research at Mayo Clinic.

Objectives

- To develop a tool for semi-automated analysis of urinary stones
- To provide a standardized report of urinary stones using reproducible metrics
- Vendor neutral
- Compatible with single and dual energy CT
- Capable of supporting clinical radiology reporting and research projects

Stone detection and analysis

- Detailed characterization of renal stones, including larger stones
- Fully automated stone detection
- Improved separation of adjacent stones
- Improved characterization of stones
- Flexibility to extract complex metrics
- Easy to export volume and other data
- Easy correlation with other imaging modalities
- Very efficient for radiologists
- Better stone size characterization, especially for complex large stones
- Improved separation of adjacent stones
- False negatives for 12/349 stones (3.4%), all <2 mm

Performance evaluation

- The use of a tool for semi-automated analysis of urinary stones using dual-energy CT was demonstrated and tested in a preoperative setting
- Clinical tests demonstrated ability to accurately characterize stone burden in patient data
- Currently used for all kidney stones imaging research in the O'Brien portfolio at Mayo Clinic
- The ability to offer a standardized report regardless of CT scanner and acquisition protocol makes it an ideal tool for multicenter collaborations in kidney stone research
- Advanced morphological metrics
- Reproducible data
- More time efficient for radiologists

Acknowledgments

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qSAS: a quantitative Stone Analysis Software for research CT imaging studies

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Abstract

Unenhanced x-ray computed tomography (CT) is the initial imaging modality of choice for patients presenting to the emergency department with acute flank pain. For patients with recurrent stone disease, CT is a critical tool for the quantification of size, number and location of stones, as well as for the assessment of metabolic activity – i.e., stone growth or new stone formation in a year. However, current clinical imaging software and workflow have proven to be inadequate to efficiently and accurately characterize kidney stones, especially for the most complex cases with multiple stones and irregular shapes. As a result, accurate quantification of renal stone burden is rarely included in a radiology report.

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Motivation

- Accurate characterization of urinary stones is crucial for patient management:
  - Stones size
  - Stones chemical composition
  - Stone texture features
  - Current clinical imaging software and workflow provides limited information for effective characterization of kidney stones

- One-dimensional metrics shown to be poor descriptors of stone burden, especially for complex stones

- Dual-Energy metrics – e.g., CT Number Ratio – and stone mineral classification only available for dual-source, dual-energy CT in current version

- qSAS: a quantitative Stone Analysis Software for

- qSAS overview of features

- Software platform:
  - Matlab-based executable file can be installed on any windows PC

- Input:
  - Any CT dataset, single or dual energy
  - Thin slices (≤1mm) required for optimal performance
  - Vendor neutral

- To support clinical radiology reporting:
  - Intuitive workflow
  - Rapid delineation of anatomy of interest
  - Automatic segmentation of stones
  - Detailed, automatic reporting of clinically relevant stone features

- To support kidney stone researchers:
  - Flexibility to extract complex metrics
  - Easy to export stone volume and other data
  - Easy correlation with other imaging modalities
  - E.g., microCT

- Stone report

1. CT stack with highlighted stone
2. Close-up view of current stone
   - Columnar to distinguish uric acid stones (red) from non-uric acid stones (blue)
3. 3D volume rendering of the stone
   - Enclosed by a box of dimensions equal to the length, width and height of the stone
4. Panel to specify the stone location within the kidney and further comments by the reader
5. Summary of stone measurements
   - Exported in excel format to enable direct incorporation in radiology report

Conclusions

- The use of a tool for semi-automated analysis of urinary stones using dual-energy CT was demonstrated and tested in a preoperative setting
- Clinical tests demonstrated ability to accurately characterize stone burden in patient data
- Currently used for all kidney stones imaging research in the O’Brien portfolio at Mayo Clinic
- The ability to offer a standardized report regardless of CT scanner and acquisition protocol makes it an ideal tool for multi-center collaborations in kidney stone research
- Advanced morphological metrics
- Reproducible data
- More time efficient for radiologists
- qSAS is scheduled to be released to the clinical and research imaging communities in summer 2018

Acknowledgments

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