Technologist-Focused Process Improvement Strategies for Implementation of Spectral CT Techniques in Radiology Workflow to Guide Renal Stone Management

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OBJECTIVE

To deploy technologist-focused education in multiple plan-do-study-act (PDSA) iterations for the purpose of incorporating spectral CT techniques into the radiology workflow to guide renal stone management

INTRODUCTION

It is well known that dual-energy computed tomography (DECT) can provide information regarding renal stone composition with a reported sensitivity of 84.6 to 100 % and specificity 93 to 100 % [1]. This technique works by using 2 distinct x-ray beam energies and leverages the different Hounsfield unit values of a particular region of interest (ROI). The composition of renal stones is important from a clinical perspective as it changes management per the American Urological Association guidelines [2]. Traditionally, stone composition was determined using lab composition analysis after successful urine straining. This method, however, requires patient education, proper technique, and is time-consuming. The ability to determine renal stone composition using a non-invasive, readily available technique such as dual energy is of great clinical utility. While the technique has been evaluated for its accuracy and reproducibility, its implementation in clinical radiologic workflow has not yet been studied.

MATERIALS AND METHODS

DECT baseline data was gathered on 2 separate CT scanners from 11/11/23 to 1/10/24. This data was not processed by CT technologists using renal stone analysis. The dual energy data was acquired without incorporation into our radiologic workflow.

To educate techs about the new workflow, meetings between the CT techs and this project's medical director were conducted. For this purpose, 3 cases were processed by a staff radiologist.

DECT data gathered on 3 separate CT scanners with dual energy stone protocols from 1/11/24 to 3/15/24 were processed by CT technologists and exported to our PACS. At this stage (PDSA 1), only images with material decomposition were generated and exported (Fig. 1) without a ROI marker.

The workflow was implemented by all technologists beginning 3/17/24 (PDSA 2).

On 4/18/24, ROI pitfalls were remediated (i.e., phleboliths, atherosclerotic calcifications, soft tissue calcifications) and data was gathered from 4/18/24 through 10/23/24 (PDSA 3).

RESULTS

From 11/11/23, to 1/10/24, 117 patients were scanned using DECT stone protocol. Of those 117, 0 studies (0%) underwent material decomposition and renal stone analysis. In total, 65 studies (56%) were positive for stones

From 1/11/24, to 3/15/24, 128 patients were scanned using DECT stone protocol. Of those 128, 128 (100%) studies underwent material decomposition and 3 (2%) underwent renal stone analysis. In total, 77 studies (60%) were positive for stones.

From 3/18/24, to 4/18/24, 81 DECTs were performed on outpatients and ED patients. Of those 81, 31 (38%) studies underwent material decomposition and renal stone analysis. 60 studies (74%) were positive for stones. Pitfalls were marked in 15 (48%) of SA cases.

From 4/18/24, to 10/23/24, 376 DECTs were performed on outpatients and ED patients. Of those 376, 46 (12%) studies underwent material decomposition and renal stone analysis. 200 studies (53%) were positive for stones. Pitfalls were marked in 4 (9%) of SA cases.

Surveys were distributed to the CT technologists asking various questions regarding their experience, training, and confidence using renal stone analysis tools in SyngoVia prior to their education session at the start of PDSA 2. Abbreviated results are as seen in Figure 2.

Low and high kV image acquisition → Material decomposition → Renal stone marker → Renal stone analysis plot

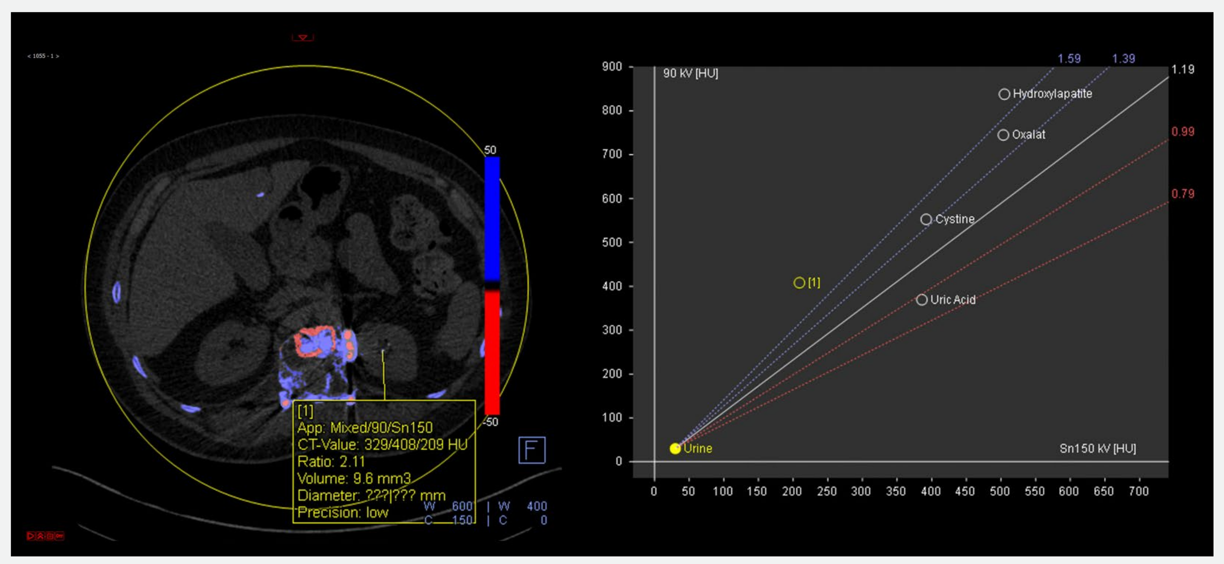
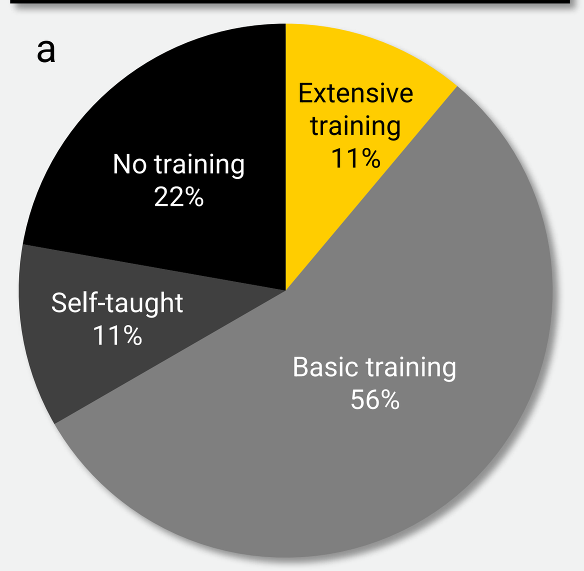


Figure 1. A view of the SyngoVia window showing both material decomposition images and the renal stone selection tool. Additionally, a renal stone analysis graph is generated predicting the stone composition.

Category	Total Scans	MD	SA	Positive Scans
Baseline	117	0	0	65
PDSA 1	128	128	3	77
PDSA 2	81	81	31	60
PDSA 3	378	378	46	200

Table 1. The total number of dual energy CT scans performed using the renal stone protocol, the number of scans that were processed in SyngoVia for material decomposition (MD), and number of scans with stone analysis (SA). Additionally, the number of CT scans that were positive for a urinary tract stone is listed.

a



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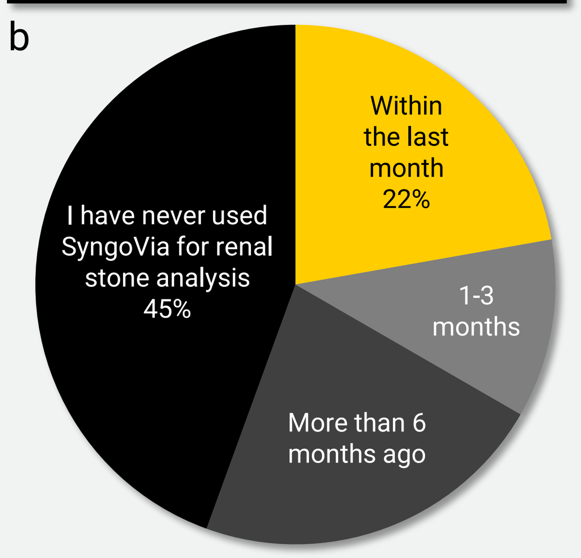

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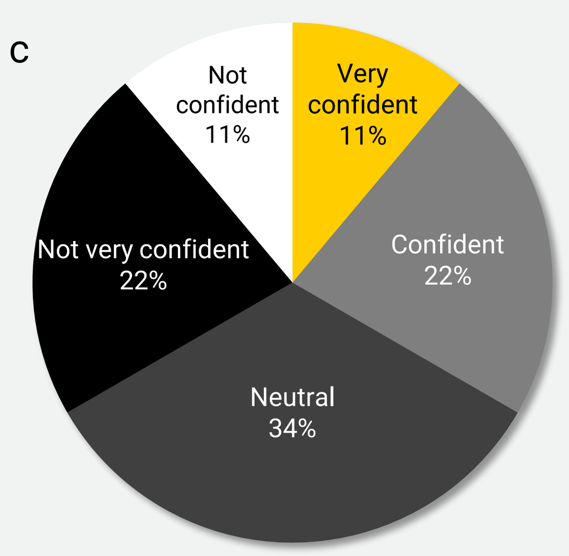

Figure 2. Pie charts displaying the results from a CT technologist survey prior to PDSA2. (a) Amount of formal training in using the renal stone analysis tools, (b) last time tech used SyngoVia, (c) confidence level of technologist in using the renal stone analysis tools in SyngoVia. (n = 9)

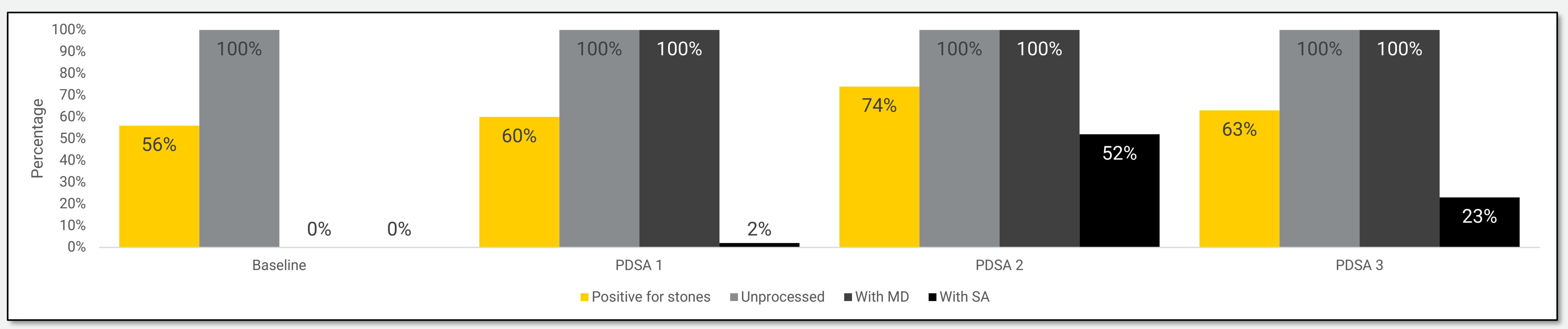

Figure 3. Bar chart depicting the relative percentage of positive studies, images reprocessed with material decomposition (MD), and stone analysis in the baseline data and in each of the intervention groups (PDSA 1, 2, and 3).

DISCUSSION

DECT has been shown to differentiate between uric acid and non-uric acid with good sensitivity and specificity [1]. However, the implementation of the information into the radiology workflow has not yet been studied. Previous studies have shown that targeted process improvement strategies can enable improved radiology quality of CTs to reduce chest CT motion artifact [5]. Here, we show that technologist-focused process improvement strategies can be implemented through a plan-do-study-act (PDSA) design with promising results.

CONCLUSIONS/FUTURE DIRECTIONS

To mitigate impact on patient care in critical settings while providing the CT technologist with real-world practice, we initially processed only scans in an outpatient setting on weekdays during the day shift. During PDSA 2 and 3, the patient scope was broadened to include emergent and inpatient day shift. Future iterations will expand the scope of this workflow in the following order: emergent overnight, inpatient overnight, weekend routine, weekend emergent, and weekend inpatient studies.

Despite our initial success, the CT techs were marking pitfalls in both positive and negative cases. After remediation, this error rate decreased from 48% in PDSA 2 to 9% in PDSA 3. However, there was an unforeseen decline in the number of cases on which techs were performing stone analysis. We attributed this to overcorrection (increased specificity at the cost of sensitivity).

Additionally, the decline in number of cases that underwent stone analysis (from 38% in PDSA 2 to 12% in PDSA 3) was confounded by updates occurring on scanners from 4/2024 to 8/2024 which disturbed the workflow and halted stone analysis by the techs.

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