Improving intraoperative radiograph diagnostic accuracy for detection of retained surgical items

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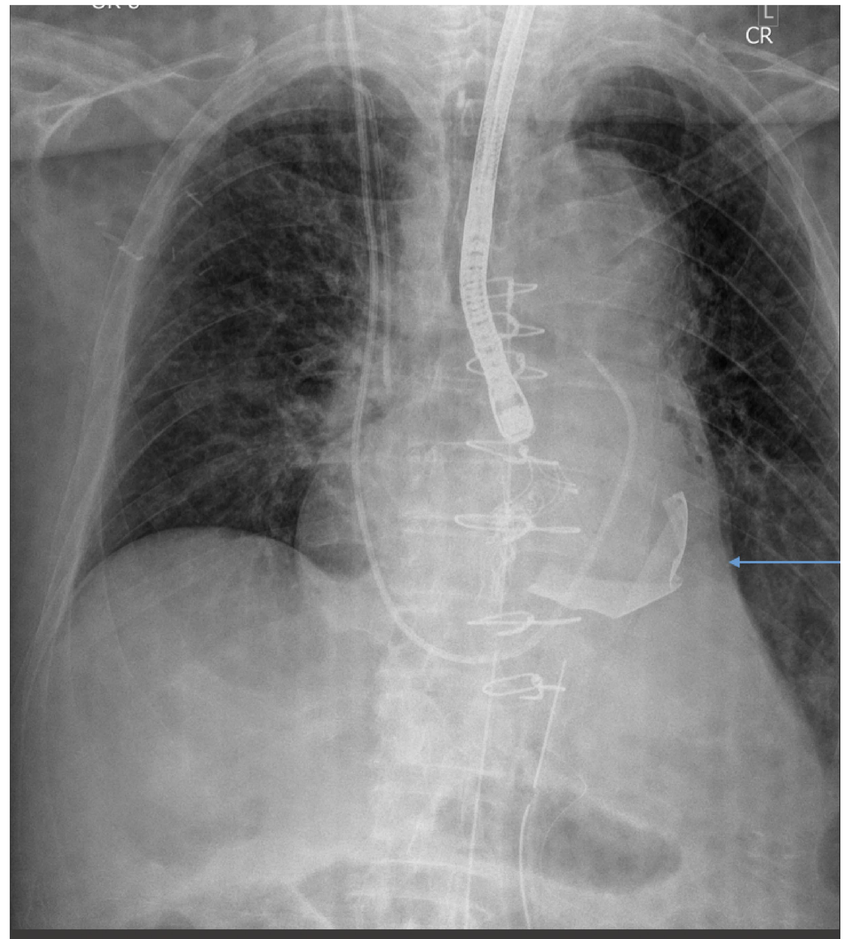
Background

A retained surgical item (RSI) is a US Joint Commission ‘never event’

- Most common RSIs: sponges and needles
- Incidence ranges widely: 1 in 1000 abdominal operations to 1 in 18,760 inpatient surgeries
- Risk factors: instrument count discrepancy, emergency surgery, unexpected change in procedure, multiple surgical teams, and high patient BMI

An intraoperative radiograph is often utilized as a last line of prior to surgical closure

- However, false negative rates have been reported up to 10-15%
- Contributing factors: uncertainty of the radiographic appearance of RSIs, obscuration by overlapping material, and time pressure of providing an immediate read



Laparotomy sponge

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Purpose

Due to the infrequent number of 'positive' intraoperative radiographs, radiologists of all levels are infrequently exposed to cases and often express uncertainty in interpretation. The purpose of the project was to increase effectiveness and accuracy of radiologist detection of RSIs on intraoperative radiographs.

Material and Methods

- Team: radiology residents, rad tech supervisor, OR manager, cross-disciplinary sponsors led by an attending radiologist
- Problem statement: to increase the confidence of radiologists in ruling out an RSI in an intraoperative radiograph.
- Interventions:
  - Standardizing the workflow
    - Streamlined telephone communication to connect to the appropriate reading radiologist
    - A positive control reference radiograph of the missing item obtained when missing item is the exam indication
    - Dictation template deployed for radiologist guidance and proper documentation
  - A 10-minute simulation based online learning module was created and disseminated
    - Included positive RSI cases, recommended approach to an intraoperative radiograph, explanatory radiographs of commonly retained sponges and needles
- Measurement of success:
  - Pre- and post-training RSI detection performance testing imbedded in the teaching module
  - Survey of radiology attendings and trainees: before the start of the QI project, at 1-week increments during intervention roll-out, and after project completion

QR code: online

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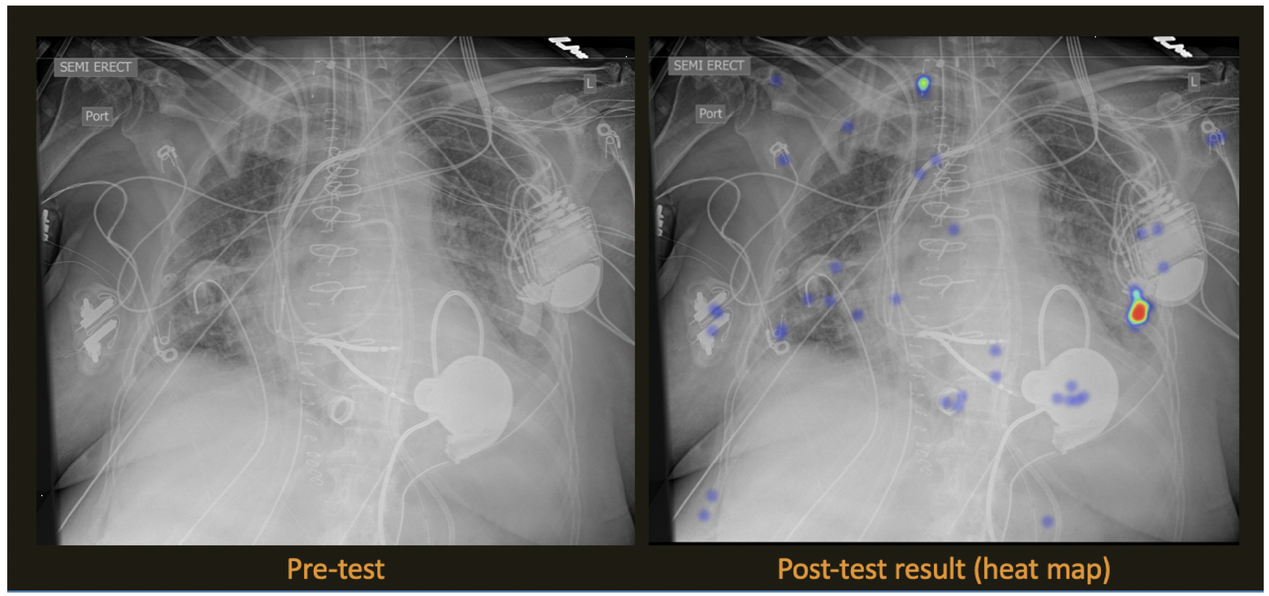
Results

Online educational module

- 107 participants. Included: radiology attendings and trainees as well as non-radiologists (OR staff, non-radiology physicians, and radiology technologists)
- Accuracy of RSI detection demonstrated statistically significant increase on the post-test of 0.94 points (95% CI 0.67, 1.21), $t(106) = 6.84$, $P < 0.001$. The mean pre-test score was 3.60 points out of a total 6 possible points (60%), compared to 4.54 points on the post-test (76%).



Pre-test | Post-test result (heat map)

Radiologist confidence

- On a 5-point Likert scale: 5 being the most confident, average radiologist RSI detection confidence increased significantly after interventions from a baseline of 3.3 to 3.9 ($z = -4.65$, $p < 0.01$)
- There was sustained increase in the confidence score for seven straight weeks at the end of the intervention period.

Other: Many radiologists provided positive feedback. Several RSIs were successfully detected during the QI process, including less common items such as surgical patties and umbilical tape, with documented images demonstrating the crucial role of positive control reference images in the accuracy of RSI detection.

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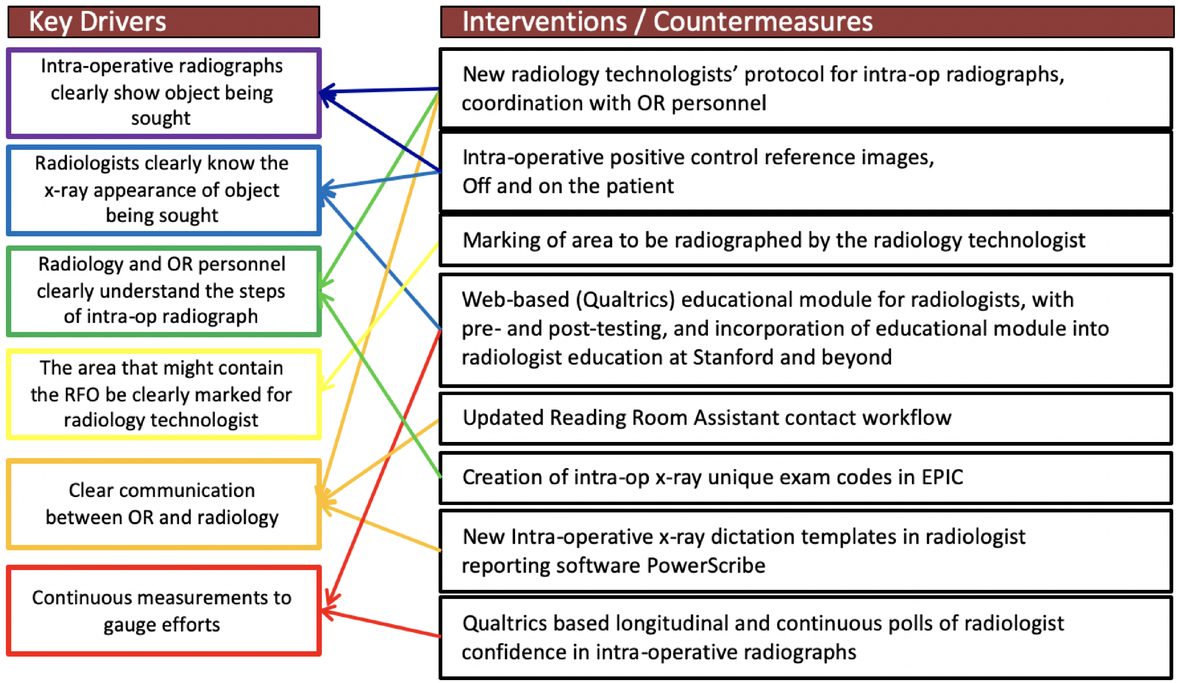
Discussion

- Multiple contributing problems were added to the root cause analysis including radiographic technique, knowledge of the radiographic appearances of RSIs, demand for OR throughout, and communication between OR and radiology. Interventions were implemented to target the underlying key drivers that promoted uncertainty in intraoperative radiographs.



- Multiprong, multidisciplinary interventions were implemented. In combination, the interventions increased the confidence of radiologists in an intraoperative radiograph's capability to rule out a RSI. In addition, the interventions were designed to be interwoven into the workflow to increase the ability to sustain these changes in the future.

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Conclusion

The QI process provided quantitative and statistically significant evidence of improved radiologist performance in RSI detection along with increased interpreter confidence. The multidisciplinary team-based approach prompted improvements in communication, standardized work-flow, and planted roots to make changes sustainable. Continued improvement in intraoperative RSI detection at our institution is ongoing.

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Figure 4. Educational module QR code

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BACKGROUND

A retained surgical item (RSI) is a United States Joint Commission 'never event' which may result in serious patient morbidity including reoperation, infection, bowel fistulization, and even patient mortality (1-4). Surgical sponges and needles are the most commonly retained items, although a multitude of other items are at risk of being left behind (Fig. 1). The incidence of RSIs ranges widely in the literature, from 1 in 1,000 abdominal operations to 1 in 18,760 inpatient surgeries (1-6). Risk factors associated with RSIs include instrument count discrepancy, emergency surgery, unexpected change in procedure, multiple surgical teams, and higher patient body-mass-index (2).

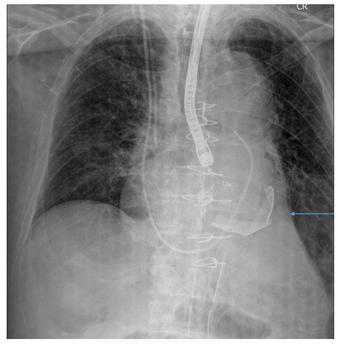

Figure 1. Laparotomy sponge

An intraoperative radiograph is often utilized as a last line of defense for discovery of RSIs prior to surgical closure. However, intraoperative radiograph false negative rates have been reported up to 10-15%, with interpretation complicated by radiologist uncertainty as to the radiographic appearance of RSIs, variability of radiographic technique, obscuration by overlapping material, and time pressure of providing an immediate read (5-8).

PURPOSE

Due to the infrequent number of 'positive' intraoperative radiographs, radiologists of all levels are infrequently exposed to cases and often express uncertainty in interpretation. The purpose of this project was to increase effectiveness of radiologists in evaluating for RSIs on intraoperative radiographs.

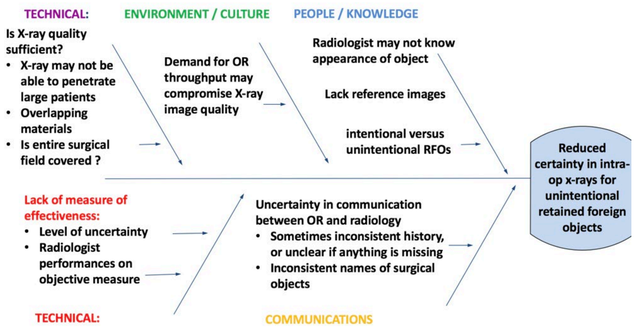

Figure 2. Root cause analysis fish bone diagram

MATERIALS AND METHODS

A multidisciplinary team was assembled to undergo a quality improvement (QI) process through a guided curriculum. An attending radiologist led the team of radiology residents, radiology technologist supervisor, operating room (OR) manager, and cross-disciplinary sponsors. An A3 framework organized the problem statement from a measurable radiology perspective: to increase the confidence of radiologists in ruling out an RSI in an intraoperative radiograph. The workflow in acquiring and evaluating an intraoperative radiograph was observed in ORs and radiology reading rooms on 'gemba' walks by team members. An anonymous survey sent out to radiologists collected perceived factors that reduced his or her confidence in the evaluation of RSIs.

Recurrent themes that arose from the survey and workplace gemba were summarized into key drivers: radiographic technique to clearly show objects, radiologists' knowledge of the x-ray appearance of RSIs, surgical extent to be clearly marked by surgery for radiology technologists, and standard operation and communication workflow for intraoperative radiographs endorsed by all stakeholders (Fig. 2). A standard protocol was developed that provided critical information to the radiologist, including the type of procedure, exam indication, and specific missing item. A positive control reference radiograph of the missing item was obtained when applicable (Fig. 3). A dedicated RSI dictation template was created for radiologist guidance and standardized documentation.

A focused 10-minute web-based interactive teaching module to improve RSI detection was created and disseminated (Fig. 4). The simulation based learning module included positive RSI cases, a recommended approach to an intraoperative radiograph, explanatory radiographs of commonly retained sponges and needles, along with pre- and post-training RSI detection performance testing. Using a Likert scale, radiology attendings and trainees at our academic medical center were surveyed regarding their confidence in intraoperative RSI detection at different timepoints: before the start of the QI project, at 1-week increments during intervention roll-out, and after project completion.

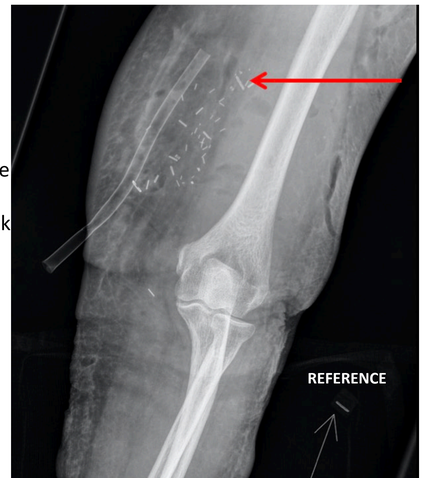

Figure 3. An intraoperative reference radiograph of a sponge was crucial in making the call that there was in fact a surgical patty in the midst of surgical staples.

RESULTS

A total of 107 participants completed the online educational module. Out of 82 radiologist participants, there were 32 residents, 12 fellows, and 38 attendings. Non-radiologist participants included OR staff, non-radiology physicians, and radiology technologists.

Accuracy in detecting RSIs from intraoperative radiographs improved significantly between the pre- and post-test. The mean pre-test score was 3.60 (± 1.53) points out of a total 6 possible points (60%), compared to 4.54 (± 1.36) points on the post-test (76%). This was a statistically significant increase on the post-test of 0.94 points (95% CI 0.67, 1.21), $t(106) = 6.84$, $P < 0.001$. Of the respondents who were trainees (radiology residents and fellows), the median pre-test score was 4.00 points out of a total 6 possible points, compared to 5.00 points on the post-test. A Wilcoxon Signed-Ranks Test indicates a statistically significant increase in post-test scores ($z = 3.51$, $p < 0.001$).

On a 5-point Likert scale with 5 being the most confident, average radiologist RSI detection confidence rating increased significantly after interventions from a baseline of 3.3 to 3.9 ($z = -4.65$, $p < 0.01$). There was sustained increase in the confidence score for seven straight weeks at the end of the intervention period. Many radiologists provided positive feedback. Several RSIs were successfully detected during the QI process, including less common items such as surgical patties and umbilical tape, with documented images demonstrating the crucial role of positive control reference images in the accuracy of RSI detection (Fig. 3).

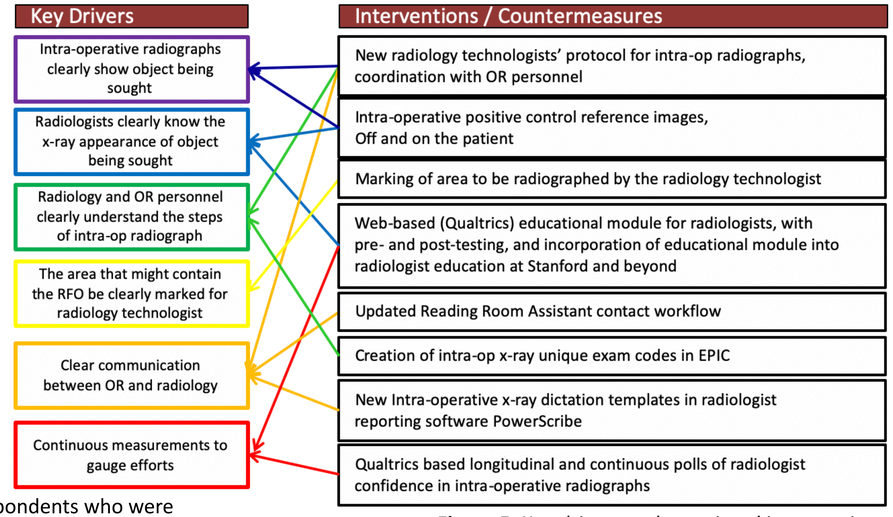

Figure 5. Key drivers and associated interventions

DISCUSSION

Multiprong, multidisciplinary interventions were implemented to target the underlying key drivers that promoted uncertainty in intraoperative radiographs (Fig. 5). In combination, the interventions increased the confidence of radiologists in an intraoperative radiograph's capability to rule out a RSI. In addition, the interventions were designed to be interwoven into the workflow to increase the ability to sustain these changes in the future.

CONCLUSIONS

The QI process provided quantitative and statistically significant evidence of improved radiologist performance in RSI detection along with increased interpreter confidence. The multidisciplinary team-based approach prompted improvements in communication, standardized work-flow, and planted roots to make changes sustainable. Continued improvement in intraoperative RSI detection at our institution is ongoing.

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