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Lauridsen, Carsten Ammitzbøl; Lefere, Philippe

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Evaluation of a radiographer tele-training programme in the interpretation of CT Colonography

By Dr Carsten Lauridsen

Colorectal cancer is one of the most common, and deadly human cancers. By early identification of suspect lesions, screening has the potential to reduce mortality. Colonoscopy remains the screening gold standard, but "virtual colonoscopy" or CT-colonography (CTC) has been shown to generate encouraging results in polyp detection.
CTC could be made more efficient and widely applicable if radiographers were trained to interpret the images they generate. Unfortunately "classical" training programs in which highly-qualified radiologists give radiographers detailed explanations can involve unacceptable increases in radiologists' work-load.
This paper describes a tele-radiology-based CTC teaching program designed to alleviate radiology work-load and summarizes the results of a practical evaluation of such training programs.

CT colonography (CTC) has now reached a high performance level for the detection of tumoral lesions in the colon, with several large trials having shown very good results in polyp detection [1-4]. These very encouraging results can however only be obtained if state-of-the-art practices in both technique and interpretation are applied by experienced teams who have been adequately trained in CTC.

Experts agree that such levels of adequacy on the part of radiographers are hard to reach, since it is recognized that CTC has a long and steep learning curve [5-7]. This was demonstrated in the large trial carried out by Rockey *et al* [8]. A review of this trial showed that technical failure and perceptual errors on the part of the observer were by far the major cause of false negative results [9].

Furthermore, despite good sensitivity for polyp detection using state-of-the-art CTC technique, the ACRIN 6664 trial [3] suffered from positive predictive values as low as 40% and 23% for polyps > 6 mm and > 10 mm, respectively, indicating a high false positive rate. As a result of this it has been deemed mandatory to improve CTC technique and interpretation through appropriate training.

The combination of the interpretation of 50-75 cases already validated by optical colonoscopy (OC) and participation in a hands-on CTC workshop was considered to be a solid basis for starting to read CTC exams[10,11]

It is generally accepted that such training processes would be improved by increasing the interaction with and feedback from the teachers [12]. This type of mentored training has been proposed in the ACR Colon Cancer Committee's white paper [10].

However population-based training programs for colorectal cancer would have to include a large number of radiologists participating in the screening process, with the risk that this could increase their workload to unacceptable levels.

Tele-training or tele-medicine, which is now widely available and easy to apply, could be a promising means of achieving the goals of introducing mentored training without resulting in unacceptable increases in work load [13].

Intuitively, the use of teleradiology education systems could be expected to be able to reduce radiologists' teaching hours and costs. This could probably be accomplished in a set-up in which a team of radiographers is supervised by a single radiologist. If the radiographers already have a sufficient level of experience, it could even be possible that the interpretation time for the radiologist be reduced significantly. The ultimate goal could be a training program in which the radiologist only checks the end-findings of the radiographers.

It was to evaluate such a system that we decided to set-up the program described below.

The author:
Carsten Lauridsen, Ph.D.
Metropolitan University College, Radiography Education, Sigurdsgade , Copenhagen
Denmark
Cala@phmetropol.dk
Direkte: +45 72 28 28 33
email: cala@phmetropol.dk

RADIOGRAPHERS AND TUTORS

Five radiographers volunteered to participate in this study. The radiographers had no experience with CTC, and only very basic experience with colonic anatomy and pathology. They however had practical experience with numerous abdominal CT and barium enema examinations.

CTC training of the radiographers was performed by two expert radiologists who had an experience of more than 6000 CTCs procedures carried out (with more than 800 procedures validated by optical colonoscopy). The radiologists also had broad experience of the organization of CTC-workshops. The training exclusively focused on the colon and did not consider extracolonic structures.

TRAINING

The training programme consisted of different stages:

1) Workshop

A 3-day workshop was organized in the teaching centre to introduce the radiographers to CTC and to normal and pathological conditions in the colon. The workshop consisted of a mix of theoretical presentations dealing with all technical and interpretational aspects of CTC as well as hands-on sessions. In total, 50 CTC cases were interpreted.

2) Training cases

Seventy-five randomly selected cases were used for further training. In these cases CTC had been performed after incomplete colonoscopy in the local department. The cases were interpreted by the radiographers at a rate of four cases every two weeks over a period of 34 weeks. Colorectal polyps ≥ 6 mm were reported and classified in two size categories (≥ 6 mm and ≥ 10 mm). Tumors were included in the calculations and analyzed as polyps, but were described separately as well. The C-RADs classification system was used [14].

All observers read the examinations independently and were blinded to all clinical findings, the colonoscopic results and each other's findings.

Image processing and interpretation in the novice department were performed with the use of a CT-workstation equipped with dedicated CTC software and allowing primary two-dimensional and three dimensional reading of the colon.

Polyps were measured with electronic calipers on the two dimensional view and recorded according to the segment (cecum, ascending colon, transverse colon, descending colon, sigmoid colon or rectum)

For each polyp detected, the radiographers annotated the segmental location, the size, the attenuation, the slice numbers per acquisition, and the distance to the anal margin of the polyp in a report which included a snap shot per polyp.

3) Test cases

Finally, the radiographers underwent a test series of 20 cases validated by optical colonoscopy. This test was drawn up by the teaching centre and consisted of five normal cases and 15 cases with colonic polyps. There were a total of 27 polyps > 6 mm with 12 and 15 polyps 6-9 mm and > 10 mm, respectively.

Identification by radiographers of polyps on CTC images requires that the radiographers receive rigorous training. A mentor-based tele-radiology system in which a limited number of highly qualified and experienced radiolists instruct several radiographers has been shown to have high potential.

The cases were interpreted by the radiographers at a rate of four cases every two weeks over a period of 10 weeks.

RESULTS

Training cases

The training cases had 69 polyps > 6 mm, with 47 and 22 polyps 6-9 mm and > 10 mm, respectively. The polyps were detected in 25 out of 66 patients (39.4%). Two colorectal carcinomas were detected and were categorized as polyps > 10 mm. The overall per-polyp sensitivity for polyps > 6mm and > 10 mm was 56.3% (95% CI 37.2 – 76.1) and 69.1% (95% CI 33.3 – 100), respectively. Overall per-patient sensitivity was 86.4% (95% CI 76.7 – 96.1) for polyps > 6mm. Overall per-patient specificity was 85.4% (95% CI 77.0 – 93.9) for polyps > 6mm.

Overall per-patient PPV was 78.3% (95% CI 64.9 - 91.7) for polyps > 6mm.

Test cases

Overall per-polyp sensitivity was 80.7% (95% CI 69.5-92.0) and 94.7% (95% CI 85.6 -100*) for polyps > 6 mm and > 10 mm, respectively. Compared to the training cases, there was a statistically significant improvement in sensitivity for polyps >6 mm in the test cases. The overall per-polyp sensitivity analysis for polyps >6 mm and >10 mm was 86.4% (95% CI 73.5 – 96.9) and 95.8% (95% CI 87.0-100) respectively. The analysis of the data from the training cases for per-polyp sensitivity showed that there was no significant difference between the radiographers.

Overall per-patient sensitivity was 92.9% (95% CI 83.1-100) for polyps >6 mm. No significant difference was observed between the training cases and the test cases in sensitivity on a per-patient basis. Overall specificity was 64.0%(95% CI 13.1-100*) for polyps >6 mm. Overall per-patient PPV was

87.8% (95% CI 71.7 – 100) for polyps > 6mm. This high level of PPV on a per patient basis indicated a low number of false positives in the test cases compared to the training cases, however the difference was not statistically significant.

All readers detected the three colorectal cancers.

DISCUSSION

Compared to other studies this training method obtained good results. Jensch et al. [15] trained two radiographers with 20 cases with feedback. In 145 patients per-polyp sensitivity was 65% and 66% for polyps > 6 mm and > 10 mm, respectively. PPV was 37.5% and 59.5% for polyps > 6 mm and > 10 mm, respectively. In another study, Burling *et al.* [16] obtained a per-polyp sensitivity of 76% for polyps > 6 mm with five radiographers. PPV for cancer was 74%. Bodily *et al.* [17] trained two radiographers with teaching files, showing improved results from 61% to 79.5% for polyps >5 mm after additional training. These results are comparable to those of the present study and confirm the efficacy of this education method.

Training in detecting polyps in a well distended colon might be appeared to be straightforward. Indeed, once a basic level of experience is reached and sufficient knowledge has been acquired concerning pathologic conditions in the colon, it could be expected that an adequate observer performance could easily be attained. However, several studies have shown that a basic experience does not guarantee performance in polyp detection [18,19]. Firstly, numerous errors of interpretation were made, resulting in false negatives [20,21]. Secondly, erroneous characterization of luminal defects may result in disappointing PPV figures. This was demonstrated in the ACRIN trial [3] with a PPV of 40% and 23% for polyps > 6 mm and > 10 mm, respectively. It should be noted that interpretation errors are not only caused by lack of experience in interpretation. Frequently, technical inadequacy is a significant source of error as was the case in the Rockey trial where 26% of important lesions were missed due to technical shortcomings in colonic preparation and distension [8].

Advantages of tele-training

The basic rationale for educating radiographers is that a team of radiographers under the supervision of one radiologist could be helpful when screening for colorectal cancer. This approach reduces radiologist time and procedural costs.

The training method used in our studies was based on mentored supervision with tele-training and had several advantages. It allowed for continuous guidance during the training period and could be considered a virtual fellowship. The radiographers could compare their findings with the reports of experienced CTC-readers. Feedback via e-mail and/or tele-conferences provided a continuous source of information. In this way, the radiographers not only learned the importance of good CTC technique, but they were also, and most important of all were faced with their own interpretational errors. During the group meetings each case was reviewed and an explanation was provided whenever a lesion was overlooked or incorrectly interpreted.

This type of mentored supervision has been considered important for CTC-training in the White Paper on CTC published by the ACR colon cancer committee [10]. Tele-training also allowed the radiographers to integrate the training in normal daily activity and learning the technique on their own workstation.

Limitations of tele-training

The training method had however some limitations. Firstly, the radiographers were tested on only 20 cases with a total of 27 polyps > 6 mm. [It should be noted however that the same number of cases was also used for testing the participants in the ACRIN trial [22]]. This means that the radiographers were more alert for polyp detection compared to a usual screening setting with low disease prevalence. Together with the realtively low number of normal cases, this probably explains the low specificity.

In conclusion, this CTC tele-training based method proved successful and could have an important and useful role in future training of radiographers in CTC.

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