Digital colonic cleansing of CT colonography images: influence on quality of 2D and 3D reconstructions

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Authors: P. Vagli, L. Faggioni, E. Picano, R. Scandiffio, A. Mantarro, P. Bemi, L. Cini, E. Neri, C. Bartolozzi; Pisa/IT
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Purpose

Fecal tagging is currently used in CT colonography (CTC) to mark and distinguish fecal contents from colonic lesions; the use of tagging material allows not only to reduce cathartic preparation but also to improve and accelerate the CTC datasets reading in 2D. "Electronic cleansing" is a spectrum of algorithms finalized to digital subtraction of the tagging material that represents the prerequisite for evaluation of tagged datasets in 3D. As a first step, we have analyzed the impact of electronic subtraction cleansing in the assessment of 2D images both in terms of images quality and diagnostic performance and subsequently we have repeated the same analysis in 3D.
Methods and Materials

We retrospectively evaluated 13 patients (polyps enriched), whom underwent CTC and resulted positive for small polyps confirmed by conventional colonoscopy. Each examination had been evaluated with and without electronic cleansing, in a total of 26 datasets, and in supine and prone position, than in a total of 52 observations. Patients underwent a three-day non- cathartic preparation followed by a same day fecal tagging protocol (500ml of water and 50 ml of diatrizoate dimeglumine 3-4 hours before CTC). Images were processed by a novel bowel cleansing plug in embedded in the pre-existent software ColonVCAR 4.5 (GE Medical Systems, Milwaukee, WI).

Two radiologists experienced in CTC, unaware of conventional colonoscopy findings, analyzed CTC datasets in 2D mode with and without digital bowel cleansing. CTC image quality (in terms of diagnostic yield and severity of digital subtraction artifacts) was assessed before and after cleansing in consensus on a per-segment basis through a five-point scale (1=poor, 2=fair, 3=good, 4= very good, 5=excellent).

Data was expressed as mean +/- standard deviation (p<0.05 indicates statistical significance).

3D images were classified in diagnostic or non diagnostic before and after cleansing and the improvement of diagnostic yield of 3D cleansed images was assessed.
Results

In 2D analysis image quality of cleansed CTC images did not differ significantly from that of source CTC datasets in the various colonic segments (cecum and ascending colon 4.31±0.48 vs 4.54±0.66; transverse colon 4.38±0.65 vs 4.38±0.51; descending colon 3.92±0.49 vs 3.92±0.64, sigmoid colon 3.38±0.77 vs 3.46±0.66; Wilcoxon signed rank test, p> 0.05) (Fig.1 on page 6).

Electronic cleansing allows a significantly higher diagnostic rate concerning 3D images; in fact, 24 findings were correctly identified (92.3%) with cleansing, than without (7.7%, Fisher’s exact test p<0.001) (Fig. 2 on page 6).

Digital colonic cleansing is a prerequisite for 3D post-processing of tagged CTC dataset, provided that cleansing works in an optimal way; this point seems highly dependent on adequate stool labeling rather than the action of cleansing itself. In fact, the persistence of stool makes tagging inhomogeneous and cleansing inefficient, leading to various types of artifacts that can be noisy in 2D and compromise the interpretation of 3D images. Inhomogeneous tagging can make reading impossible, causing anomalous subtraction in extracolonic structures and intraluminal contrast persistence in particular in sigmoid colon; this can occur in case of too early scans (less than 3 hours after oral administration of tagging material) where the density of tagging material can be under the threshold of subtraction (Fig. 3 on page 7-4 on page 8).

Blurring is an edge artifact and results in an ill-defined aspect evident in mucosal-lumen interfaces, it is related to the inner actions of the various algorithms at the level of the interfaces and can be annoying without causing interpretative mistakes in 2D as well as in 3D, while tagging remnants may determine interpretative mistakes in 3D (fig. 6 on page 9-7 on page 10).

Electronic cleansing does not lead to a significant improvement of 2D images, and cleansing-related artifacts although noisy did not impair the diagnostic yield of CTC datasets in any case.

Furthermore, in 2D interpretation, no conspicuity, morphology or size modification of lesions were observed (fig. 8 on page 10)

This algorithm is also handling in use; for both readers, the mean evaluation times with subtracted images was approximately 1.5 min longer that with native images in 2D.

The reliability of the cleansing algorithm quantified in 2D have kicked off its evaluation in 3D. Without cleansing 3D evaluation is not possible, as demonstrated in our data (fig. 9 on page 11-10 on page 11); with cleansing, sensitivity is high, particularly in datasets with homogeneous, high density tagging.
In case of poor quality of tagging, images in 2D can be noisy and lesions can be missed in 3D (fig. 11 on page 12).
Fig. 0: Image quality of cleansed CTC images did not differ significantly from that of source CTC datasets in the various colonic segments. We can notice how the scores tend to reduce moving from the right to the left colon according to an increasing inhomogeneity of the tagged content.

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Fig. 0: 3D lesion detection rate dramatically improves with cleansing.

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**Fig. 0:** Limit case where the cleansing software operates very well providing an excellent result at the transverse colon where the intraluminal content is concentrated while at the level of the sigmoid the intraluminal content density is lower and the software performance is very poor operating in the same scan only at the level of the ileal loops and at the cortical bone.

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Fig. 0: Blurring is particularly evident at the posterior aspect of the right colon (arrow).

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Fig. 0: In 2D the presence of some residues of tagging material around a lesion (polyp of the transverse colon) can be annoying but do not impair its evaluation. The same case in 3D: the presence of a conspicuous polyp can remain totally unsuspected without cleansing in 3D.

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Fig. 0: In 2D interpretation, no conspicuity, morphology or size modification of lesions were observed.

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Fig. 0: Polyp of the cecum partially lying the fluid tagging level in both decubitus clearly detected with and without cleansing in 2D and remaining completely undetected in 3D without electronic cleansing.

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**Fig. 0:** Inhomogeneous tagging (bubble air in this case) do not significantly impair the conspicuity of the lesion (polyp of the cecum) in 2D after cleansing but it renders virtually impossible the visualization of the posterior aspect in 3D.

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Conclusion

In our opinion the better way to assess the reliability of cleansed images was a preliminary analysis on 2D, and the good results obtained have prompted us to apply this algorithm in 3D. We have demonstrated how diagnostic rate of 3D cleansed images can be affected only in the case of not adequate stool labelling rather than the action of cleansing itself. The artifacts inherent in the software although noisy do not impair diagnostic performance both in 2D and 3D.
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