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Changes in Adenoma Detection Rate From Full-Spectrum Endoscopy to Standard Forward-Viewing Endoscopy

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Goals: The aim was to investigate the adenoma detection rate (ADR) of endoscopists who have used full-spectrum endoscopy (Fuse) for 3 years and revert back to traditional forward-viewing endoscopes (R-TFV) at an ambulatory surgical center.

Background: Traditional forward viewing (TFV) endoscopes have 1 camera and provide an angle of view of 140 to 170 degrees, whereas Fuse provides a 330 degrees view through the addition of 2 side cameras. It has previously been reported that Fuse increased the ADR by 5.4% when compared with previous rates using TFV. Fuse is no longer commercially available. The ADR of endoscopists who revert back to TFV is unknown.

Study: We conducted a retrospective analysis of data examining the ADR from average risk screening colonoscopies at a 5-room ambulatory surgical center where endoscopists transitioned from TFV to Fuse in April 2014 and then reverted back to TFV in 2016. The primary outcome was ADR. Secondary outcomes were ADR for advanced and right-sided adenomas.

Results: A total of 6110 procedures were reviewed. The ADR was 23.70% for TFV, 29.02% for Fuse and 28.88% for R-TFV. The ADR for advanced adenomas was 3.8% for TFV, 6.0% for Fuse and 7.3% for R-TFV. The ADR for right-sided adenomas was 13.0% for TFV, 16.7% for Fuse and 16.0% for R-TFV. The results for all 3 categories showed a statistical difference between TFV and Fuse as well as between TFV and R-TFV. There were no statistical differences between the ADR of Fuse compared with R-TFV.

Conclusions: During R-TFV, endoscopists are able to maintain their increased ability to detect adenomas. This would suggest that there was a change in behavior in endoscopists using Fuse that was durable.

Key Words: polyps, adenomas, CRC screening, colorectal cancer, full spectrum endoscopy

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Colorectal cancer (CRC) has been shown to be derived from the malignant transformation of normal colonic mucosa cells to benign adenomatous colon polyps to cancer through the adenoma-carcinoma sequence. The removal of adenomatous polyps during colonoscopy has been shown to decrease the development of CRC up to 90%.[1] Screening and surveillance colonoscopy with the removal of adenomatous polyps has decreased mortality from CRC by up to 53%.[2]

Interval CRC, cancer that occurs in between screening colonoscopies, is thought to develop because of adenomas that are missed during screening colonoscopies. It has been found that the adenoma and cancer miss rate can be as high as 27%.[3] Tandem colonoscopy trials have reported adenoma miss rates ranging from 20% to 44%.[4] Adenoma detection rate (ADR) has been shown to predict risk of interval CRC following screening colonoscopy and higher ADRs are associated with a decreased risk of interval CRC. A 1% improvement in ADR can correlate to a 3% decrease in interval CRC at 10 years.[5] ADR has therefore emerged as an important quality indicator for endoscopists.[3]

Traditional, single camera, forward-viewing colonoscopes (TFV), with a 140-degree to 170-degree field of view can leave more than 10% of the mucosal surface unexamined.[6] Full-spectrum colonoscopy (Fuse; Boston Scientific, MA) is an endoscopic platform that provides a 330-degree view of the colon with the addition of 2 side-facing imagers to the traditional forward facing imager (FUSE). The views provided by these imagers importantly include the proximal aspect of haustral folds, where more than 70% of missed lesions may be located.[7] The estimated potentially omitted adenomas without the side-viewing cameras of FUSE has been shown to be 29% for men and 19% for women.[8] FUSE has also been shown to outperform conventional colonoscopy with right-colon scope retroflexion in the detection of missed adenomas, both overall and in the proximal colon, even when performed by experienced endoscopists.[9] Our group previously reported that FUSE increased overall center-wide ADR by 5.4% when compared with TFV in a real world community based setting.[10]

In 2016, the manufacturer of FUSE endoscopes announced that they would no longer manufacture new FUSE endoscopes and would eventually stop supporting the platform. There are still FUSE platforms in use today, but many endoscopists who adopted FUSE have already reverted to using a traditional, forward-viewing single camera endoscope. It is not known if there is a change in the ADR when endoscopists previously using FUSE return to using a traditional, single camera, forward viewing colonoscope (R-TFV).

MATERIALS AND METHODS

Study Setting and Patient Population

A retrospective study was performed at Carnegie Hill Endoscopy, a single specialty, community-based, 5-room ambulatory surgical center (ASC) located in New York, NY. ASC converted from using high definition, single

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camera, forward-viewing EC-530L Fujinon colonoscopes (Fujinon, Saitama, Japan) with a 140-degree field of view to FUSE colonoscopes in April 2014. First-generation FUSE endoscopes were replaced with second-generation devices in December 2014. Differences between first-generation and second-generation FUSE included a software upgrade, which led to improved image brightness and clarity, as well as the transition from 3 separated standard definition monitors to 1 high definition monitor in which the images merged onto 1 screen. In December 2018, the ASC transitioned back to a traditional, high definition, single camera, forward-viewing EC-760R-V/L Fujinon colonoscope (Fujinon, Satiama, Japan) with a 170-degree field of view.

Three cohorts were included in this study: (i) colonoscopies performed with TFV from January 1, 2013 to September 30, 2013; (ii) colonoscopies performed with FUSE from January 1 to September 30 2015; and (iii) colonoscopies performed with R-TFV from January 1 to September 30, 2019. Each cohort was chosen as the start date to reflect the first full month after adoption of the specific equipment.

Colonoscopies with an indication of CRC screening in patients aged 50 years and older were included in the data. Procedures performed for indications other than average risk CRC screening were excluded. Individuals at increased risk for CRC (history of inflammatory bowel disease, history of CRC in a first-degree relative, history of a genetic anomaly that would predispose an individual for a higher risk of developing colon cancer) were also excluded. Colonoscopies with unknown or suboptimal bowel preparation quality (defined as fair or poor preparation as determined by the endoscopist) were excluded. Only providers who performed at least 20 screening colonoscopies during each cohort period were included. All colonoscopies were performed by attending gastroenterologists. Gastroenterology fellows did not perform or assist with the colonoscopies.

Data Collection

A list of colonoscopies fitting the study's inclusion criteria was generated using ASC's documentation platform, Provation (Provation Medical, Minneapolis, MN). The medical charts of eligible subjects were then reviewed. Basic demographic data including gender and age were recorded. Colonoscopy reports were reviewed to document the endoscopist, procedure date, quality of the bowel preparation, completeness (defined as whether the cecum was reached), cecal withdrawal time, the number of polyps removed and whether the polyps were proximal to the hepatic flexure. Proximal colon lesions were noted because interval CRC occurs more frequently in the right colon.[11,12]

Pathology reports were reviewed and samples were classified in one of the following categories: clinically insignificant (normal mucosa, inflammatory, lymphoid aggregate, hyperplastic), nonadvanced adenomas (tubular adenomas, sessile serrated adenomas, sessile serrated lesions), adenomas with advanced features (villous component, high-grade dysplasia, size 10 mm or greater), adenocarcinoma and non-adenocarcinoma malignancy. The largest diameter as measured by the pathologist was used to determine polyp size. In the case of piecemeal resection, the largest diameter of each constituent sample was aggregated to calculate the documented polyp size.

Study Endpoints

The primary study endpoint was the differences in absolute change in center-wide ADR between the 3 cohorts. ADR was defined as the number of screening colonoscopies in which at least 1 adenoma or cancer was identified, divided by the total number of screening colonoscopies performed. Secondary endpoints included differences in the detection rate of advanced adenomas (A-ADR) and adenomas of the proximal colon (P-ADR). The mean number of adenomas per colonoscopy was also calculated. An adenoma was advanced if it was >9 mm, included a villous component or contained high-grade dysplasia. The proximal colon was defined as the cecum, ascending colon and hepatic flexure. Center-wide ADRs were calculated for each 9-month period as well as for 3 trimesters comprising the study periods in 2013, 2015, and 2019. Months 1 to 3 within each 9-month period were defined as "Trimester 1," months 4 to 7 were defined as "Trimester 2," and months 7 to 9 were defined as "Trimester 3."

Changes in ADR among individual endoscopists were also evaluated. ADR was compared between providers with a TFV ADR $<25\%$ and $>25\%$.

Statistical Methods

Statistical analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC) software. All statistical tests were 2-sided. Statistical significance was defined as a P-value <0.05. No formal sample size calculation was performed. Instead, all subjects who fulfilled the inclusion and exclusion criteria during study dates were included. Continuous variables are summarized with a mean and SD as well as the median and categorical variables by a count, percentage, and absolute change by type of endoscope and provider. Continuous variables were compared between the 3 types of endoscopes with analysis of variance. Categorical variables were compared between the 3 types of endoscopes with a χ^2 test. Withdrawal time was compared between the 3 types of endoscopes with a Kruskal-Wallis test. ADR for each type of endoscope was compared between trimesters with a Cochran-Armitage trend test. ADR differences were compared between races, genders, and providers having a baseline ADR below/above 25% with a Breslow-Day test.

RESULTS

A total of 6340 screening colonoscopies were performed during the 3 study periods. One hundred sixteen colonoscopies from the TFV cohort, 76 colonoscopies from the FUSE cohort, and 101 colonoscopies from the R-TFV cohort were excluded because of suboptimal preparation (prep that was either poor, inadequate, or uncharacterized). The remaining 6047 colonoscopies with excellent or good bowel preparation were included in the final study population. The TFV cohort included 1665 screening colonoscopies. The FUSE cohort included 2270 screening colonoscopies. The R-TFV cohort included 2112 screening colonoscopies. The characteristics of each cohort are described in Table 1. There was a statistically significant difference in mean age ($P=0.02$) between TFV and FUSE. There was no statistical difference in mean age between FUSE and R-TFV as well as between TFV and R-TFV. There was no statistical differences in gender distribution among the 3 groups (Table 1).

Colonoscopies were performed by 19 endoscopists. Endosocpists completed a median of 79 screening colonoscopies during the TFV observation period (range: 23 to 184), 117 colonoscopies during the FUSE observation

TABLE 1. Patient Characteristics

Characteristic	TFV	FUSE	R-TFV	*P*, TFV vs. Fuse	*P*, TFV vs. R-TFV	*P*, Fuse vs. R-TFV
Screening colonoscopy cases reviewed	1781	2346	2213			
Cases excluded because of suboptimal prep	116	76	101			
Cases included in study (n)	1665	2270	2112			
Mean age (y)	59.61	60.18	60.16	0.02	0.05	0.05
Sex						
Male	776	1037	924			
Female	920	1265	1188			
Male (%)	45.75	45.05	43.75	0.66	0.22	0.39

FUSE indicates three camera, full spectrum endoscopy; R-TFV, return to traditional, single camera, forward viewing endoscopy; TFV, traditional, single camera, forward viewing endoscopy.

period (range: 37 to 325), and 89 during the R-TFV observation period (range: 44 to 229).

Median cecal withdrawal time was 9 minutes 53 seconds in the TFV cohort, 8 minutes 57 seconds in the FUSE cohort, and 9 minutes in the R-TFV cohort. There was a longer withdrawal time with TFV as compared with the other 2 groups ($P < 0.001$).

Overall centerwide ADR improved from 24.1% with TFV to 29.6% with FUSE ($P < 0.01$), but did not change from FUSE to R-TFV, 29.6% to 28.9% ($P = 0.09$). The number of adenomas detected per case increased significantly from 0.32 with TFV to 0.42 with FUSE ($P < 0.0001$), but did not change significantly from FUSE to 0.45 with R-TFV ($P = 0.27$). ADR for advanced adenoma improved from 3.8% with TFV to 5.8% with FUSE ($P < 0.01$). ADR for advanced adenoma did not change significantly from FUSE to R-TFV, 5.8% to 7.3% ($P = 0.07$). ADR for proximal colon neoplasia improved from 12.8% with TFV to 15.9% with FUSE ($P < 0.01$). ADR for proximal colon neoplasia did not change significantly from FUSE to R-TFV, 15.9% to 16.0% ($P = 0.52$) (Fig. 1).

Among male patients, overall ADR improved from 28.5% with TFV to 34.8% with FUSE (+6.3%; $P < 0.01$). There was no significant change in ADR among male patients between FUSE and R-TFV (−1.8%; $P = 0.54$). Among female patients, overall ADR improved from 20.5% with TFV to 25.5% with FUSE (+5.0%; $P < 0.01$). There was no significant change in ADR among female patients between FUSE and R-TFV (+0.2%; $P = 0.60$) (Table 2).

A total of 2 cancers were identified in the TFV cohort (0.12%). Both cancers were adenocarcinomas. Nine cancers were identified in the FUSE cohort (0.40%). Seven of the cancers in the FUSE cohort were adenocarcinomas, 1 was a neuroendocrine tumor and 1 was a squamous cell carcinoma of the anal canal. Six cancers were identified in the R-TFV cohort (0.28%). Five were adenocarcinomas and 1 was a neuroendocrine tumor.

Eight of the 19 providers had an ADR above the recommended benchmark of 25% using TFV.[3] After transitioning to FUSE, 13 of 19 providers with FUSE met the recommended benchmark for ADR. There were 6 providers who went from not meeting the recommended criteria to meeting the criteria and 1 provider who previously met the criteria who no longer met the criteria. During the R-TFV cohort, the ADR benchmark of above 25% was met by 13 of 19 providers. One provider who previously met the criteria in FUSE no longer met the criteria and 1 provider who previously did not meet the criteria in FUSE met the criteria in R-TFV (Fig. 2).

Overall ADR did not change on a trimester-by-trimester basis during the TFV observation period ($P = 0.77$, T1: 25.68, T2: 22.34, T3: 24.67). Overall ADR increased on a trimester-by-trimester basis during the FUSE observation period ($P < 0.01$, T1: 26.16, T2: 29.15, T3: 32.91). Overall ADR decreased on a trimester-by-trimester basis during the R-TFV observation period ($P < 0.01$, T1: 32.04, T2: 29.31, T3: 24.81).

DISCUSSION

In this study we compared the ADR from screening colonoscopy exams with TFV, FUSE, and R-TFV in an observational cohort of over 6000 patients at a single speciality, community-based ASC. We found that the centerwide ADR of 24.1% when using TFV increased to 29.6% after implementation of FUSE. When endoscopists reverted to a traditional single camera, forward viewing endoscope, the ADR of 28.9% remained not statistically different from FUSE and significantly increased when compared with their baseline ADR when using TFV, before FUSE. The detection of advanced neoplasias as well as proximal neplasias also increased significantly when endoscopists transitioned from TFV to FUSE, and remained high when they transitioned from FUSE to R-TFV.

New endoscopic technologies have been developed with the goal of improving ADR by increasing both the quantity and quality of visualized colonic mucosa. Strategies have included adding ancillary rear-viewing cameras,

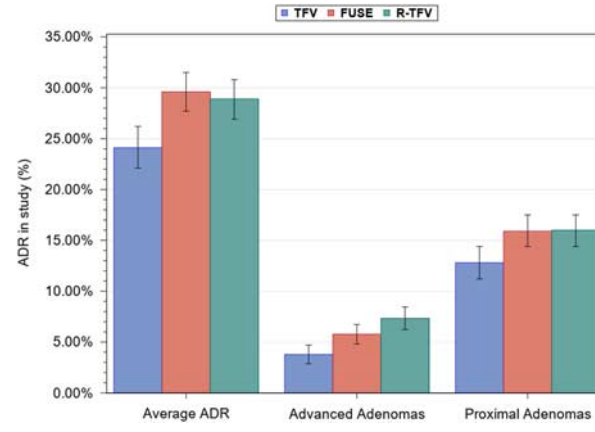

FIGURE 1. Overall ADR during the 3 cohort. ADR indicates adenoma detection rate; FUSE, 3 camera, full spectrum endoscopy; R-TFV, return to traditional, single camera, forward viewing endoscopy; TFV, traditional, single camera, forward viewing endoscopy. full color online

TABLE 2. ADR With TFV, FUSE, and R-TFV

Study Endpoint	TFV	FUSE	R-TFV	*P*, Between TFV and Fuse	*P*, Between TFV and R-TFV	*P*, Between Fuse and R-TFV
Median withdrawal time	9:53	8:57	9:00	0.08	0.04	0.03
Cases with adenomas	402	669	610			
Cases without adenomas	1294	1633	1502			
ADR in study (%)	24.1	29.6	28.9	< 0.001	< 0.01	0.09
Females with polyp	184	313	305			
ADR if females (%)	20.0	24.7	25.7	< 0.01	< 0.01	0.60
Males with polyp	218	356	305			
ADR in males (%)	28.1	34.3	33.0	< 0.01	0.03	0.54
Advanced adenomas detected	64	138	155			
ADR for advanced adenoma (%)	3.8	6.0	7.3	< 0.01	< 0.0001	0.07
Proximal adenomas detected	220	384	337			
ADR for proximal adenomas (%)	13.0	16.7	16.0	< 0.01	< 0.01	0.52
Mean number of adenomas/case	0.32	0.4	0.45	< 0.0001	< 0.0001	0.27
Median cases per endoscopist	79	117	111			

ADR indicates adenoma detection rate; FUSE, 3 camera, full spectrum endoscopy; R-TFV, return to traditional, single camera, forward viewing endoscopy; TFV, traditional, single camera, forward viewing endoscopy.

balloons, cuffs, rings, and caps to the endoscope tip to flatten haustral folds.[13–21] Other technologies have attempted to detect more polyps by improving colonoscope optics.[22–26]

In addition to advances in technology that enhances visualization, studies have also shown that the behavior of the endoscopists can affect ADR and the incidence of interval colon cancer. A withdrawal time of > 6 minutes is associated with higher ADR and a reduction in the incidence of interval CRC after screening colonoscopy.[27,28] It has been shown that when endoscopists are aware that they are being observed, their median withdrawal time increases from 4.5 to 7.3 minutes, leading to an increase in ADR from 21.4% to 36.0%.[29] Formal quality improvement programs focused on education have been shown in a prospective randomized study to increase absolute ADR from 7% to 12%.[30,31] The endoscopists in this study were given quarterly report cards that included cecal intubation rate, prep quality, withdrawal time, and ADR with comparisons to their peers at the ASC and national averages, but no other feedback was provided. These quarterly report cards were implemented for several years before 2015.

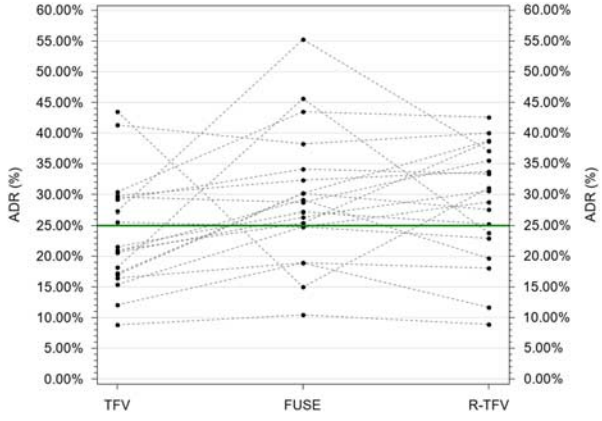

FIGURE 2. Individual endoscopists ADR. ADR indicates adenoma detection rate; FUSE, 3 camera, full spectrum endoscopy; R-TFV, return to traditional, single camera, forward viewing endoscopy; TFV, traditional, single camera, forward viewing endoscopy. full color online

The improved field of view because of technology, when endoscopists transition from TFV to FUSE, can explain the increase in ADR. However, once endoscopists using FUSE revert back to using a traditional, single camera, forward viewing endoscope with a decreased field of view, they are still able to maintain an ADR similar to when they were using FUSE. This ability to maintain an increased ADR may have resulted in changes in behavior of endoscopists using FUSE, who learned that they may have been missing neoplasias previously, when using TFV. These changes may have included looking more carefully behind folds with tip deflection to compensate for the decrease in field of view.

It has been shown that endoscopic quality improvement programs may have durable effects and are not a "one and done" phenomenon.[32]

Most recently, the variability among endoscopists to detect adenomas is being addressed through technology with the introduction of artificial intelligence employing real-time computer aided detection of colorectal neoplasia. Artificial intelligence modules which are added onto existing endoscope platforms have been shown to have an absolute ADR increase of 14.4%.[33]

The main limitation of this study is that it was retrospective in nature. It was difficult to standardize and ensure collection and recording of all relevant data, such as demographic information. The ASC stopped collecting race as part of the routine demographics collection before 2018 and therefore, this characteristic was not analyzed in the study. Studies have shown that there are racial differences in adenoma and colon cancer rates.[34,35]

Although the endoscopes used in TFV and R-TFV were produced by the same manufacturer, the endoscopes were not identical. The endoscopes used in TFV had a field of view of 140 degrees, whereas the endoscopes used in R-TFV had a field of view of 170 degrees. Furthermore, the additional 5 years' experience performing endoscopies from the first to final migration may have led the cohort of endoscopists to maintain their high ADR, but this cohort was already an experienced group with a median number of years after fellowship training of 23 (range: 7 to 33).

The main strength of the report is that it reflects results from a large population of patients in a real-world clinical setting. The procedural data was extracted from the same 19 endoscopists. The components of the ASC including the providers, the ancillary staff, the ancillary endoscopy equipment, and the patient referral base remained the same across all 3 cohorts. The analysis was restricted to average risk patients that had achieved good to excellent bowel preparation. Shorter cecum withdrawal times in the FUSE cohort was noted, suggesting that increased adenoma detection was not the result of extratime spent examining the colon. The baseline detection rates are comparable to other large reports of screening colonoscopies.[25]

Although FUSE scopes are no longer manufactured, endoscopes with enhanced field of views can be an important training tool that can teach even experienced endoscopists that they were previously missing adenomas. The images from the side cameras can be suppressed from the endoscopist performing the procedure, but made available to a preceptor who has access to images from all 3 cameras. Any missed neoplasia detected by the side cameras that are missed by imaging with the forward viewing camera alone, can then be revealed by the preceptor to the performing endoscopist in real time. This may lead to an improvement in ADR when the trainee endoscopist returns to using TFV.

Transitioning from a single view endoscope to a 3-camera endoscope with an enhanced field of view can increase ADR. This improvement persists even when the endoscopist reverts from using a 3-camera endoscope back to using a single view endoscope, but appears to erode with the passage of time. Endoscopes with enhanced field of views can be an important training tool used to improve ADR.

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