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Original Research Article

Preoperative evaluation of colorectal cancer: accuracy of tumor localization by computed tomography scan and colonoscopy in comparison to the surgical findings

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Abstract

The accuracy of colorectal tumor localization is most significant in the preoperative stage. Colonoscopy and CT tests are extremely important for tumor localization and are usually used as complementary tests. This study examined the level of accuracy of abdominal CT and colonoscopy in the localization colorectal tumors, based on the findings of these tests in the same patient and in comparison with the precise location determined during the surgery. The effect of several factors (tumor size, morphology, pathology) on the accuracy of tumor localization was examined. A retrospective observational study conducted in patients who underwent surgery for colorectal tumor resection at the Hillel Yaffe MC between 2007 – 2014. 256patient charts containing preoperative colonoscopy report, CT, surgical and tumor pathology report were reviewed. The tumor location as determined by colonoscopy and CT was compared to its exact location in surgery. Mean age 68 years. 136 (53%) females. Correlation between CT and surgery was 61% (kappa 0.08) between colonoscopy and surgery was 81% (kappa 0.77).Overall correlation between CT, colonoscopy and surgery was 54%. Tumor size was directly proportional to the level of correlation between the CT and surgery. No single parameter influenced the level of correlation between the colonoscopy and the surgery. CT scan failed to diagnose the tumor in one fifth of the patients. To conclude, colonoscopy is more accurate in ensuring proper preoperative tumor localization. CT scans should be further used as a complementary test, mainly to determine the extent of disease spread.

Keywords: Colorectal cancer, Localization, CT, Colonoscopy, Surgery

INTRODUCTION

Colorectal cancer (CRC) is the third most common cancer in the western world, and a major cause of morbidity and mortality (Haggar and Boushey, 2009; Boyle and Langman, 2000). The disease is slightly more common in males, with annual incidence rates of 48/100,000 in males and 38/100,000 in females (Ferlay et al., 2012). The prevalence of the disease increases with age, and the average age at the time of diagnosis is 68 (Howlader et al., 2014). The symptoms of colon cancer may include abdominal pain, weight loss, fecal blood, or changes in bowel movement habits etc. (Feldman et al., 2010). The risk factors for CRC can be classified as modifiable risk factors, such as a lack of physical activity, a high fat diet, a low fiber and low calcium diet, smoking and alcohol consumption (Haggar and Boushey, 2009; Tárraga et al., 2015); or as non-

modifiable risk factors such as old age, personal or family history of polyps or colorectal cancer, inflammatory bowel disease or genetic familial syndromes such as Lynch Syndrome or polyposis (Haggar and Boushey, 2009; Feldman et al., 2010). Based on the known prevalence of tumor distribution in various parts of the bowel, the majority of the tumors are located in the descending and distal colon (40% in the left and sigmoid colon, 30% in the rectum and rectosigmoid colon) (Seigel et al., 2014). Compared to other cancers, the survival rates for this disease are high, with a 5 year survival rate of 65%; the improvement in survival is attributed to the improved efficacy of oncological and surgical treatments (Siegel et al., 2009). The risk factors for mortality include old age, disease stage and male sex (Howlader et al., 2014). Over the last 10 years, the decreasing mortality rates observed in the United States are attributed to screening programs for early detection of the disease (Chu et al., 1994).

Accurate localization of CRC is most important for the treatment of colorectal cancer patients, and erroneous localization may lead to difficulties and delays during the surgery, especially in laparoscopic procedures. The 11% - 21% error rate (Cho et al., 2007; Stanciu et al., 2007; Lam et al., 1998; Piscatelli et al., 2005) reported in the literature indicates that accurate localization is a significant challenge. The study by Hilliard (Feldman et al., 2010) indicates that endoscopic examination is often incapable of establishing the precise distance from the anus, thus making localization of the tumor during surgery difficult. Piscatelli (Piscatelli et al., 2005) found that tumor localization by colonoscopy may be inaccurate, thus leading to surgical procedures different from those originally planned in 11% of the cases. Marking the tumor during colonoscopy increases localization accuracy but does not ensure easy and safe identification during the surgery (Cho et al., 2007; Kozol et al., 2007; Kim et al., 1997). In the rectum, the precise distance between the tumor and the anus is an important consideration when selecting the appropriate therapeutic approach, both preoperatively and postoperatively. For tumors located in other parts of the colon, erroneous tumor localization may lead to difficulties finding the tumor during the surgery, thus requiring intra-operative colonoscopy to establish its location with certainty.

Intra-operative colonoscopy is also associated with prolonged duration of surgery and inflation of the bowel, which may later preclude laparoscopic bowel resection (Kim et al., 1997).

At times, the colonoscopy precedes the CT scan, and the oncologist or the surgeon then requests that the CT be performed, as is considered common practice for preoperative cancer staging (Lipof et al., 2005; Voloyiannis et al., 2008; Mauchley et al., 2005).

At times, the CT scan is the first test that detects the lesion, whereas subsequent colonoscopy locate sit. It is not clear which of the 2 tests is more accurate in defining the lesion location in the colon, and which parameters affect this accuracy.

The study objective

1. The primary objective of this study was to compare the efficacy of CT with the efficacy of colonoscopy for accurate localization of CRC, based on the precise tumor location established during surgery.
2. The secondary objective was to identify factors which may affect the accuracy of tumor localization by CT and/or colonoscopy, such as tumor location, size, morphology, grade or stage (extent of spread).

MATERIALS AND METHODS

A retrospective observational study conducted among patients who underwent surgery for CRC tumor resection at the Hillel Yaffe Medical Center between 2007 and 2014. A list of two hundred fifty-six patient charts containing the following data was reviewed: preoperative colonoscopy report, preoperative CT report, surgical report and tumor pathology report.

Tumor location in the bowel was classified according to 7 segments: the cecum, ascending colon, transverse colon including flexures, descending colon, sigmoid colon, rectosigmoid colon and rectum.

Tumor location as determined by colonoscopy and abdominal CT was compared to the precise location based on the surgical report.

The description in the surgical report was considered to be the "gold standard". Tumor localization was considered to be "inaccurate" if its location as determined during surgery differed from the location determined by CT or colonoscopy.

The study population

Inclusion criteria: All of the patients who underwent surgical resection of CRC between 2007 and2014 at the Hillel Yaffe Medical Center, for whom the surgical report, preoperative colonoscopy and CT reports, and the pathology report were available.

Exclusion criteria: Patients for whom at least one of the aforementioned reports was missing.

RESULTS

The study included 256 patients diagnosed with CRC, at mean age of 68 ± 13 years, about half of them- 136 (53%) females; all of them underwent preoperative evaluation by colonoscopy and CT. Tumor location based

Table 1. Distribution of tumor locations

	Surgery	CT	Colonoscopy
Cecum	25 (10%)	27 (11%)	27 (11%)
Ascending colon	40 (16%)	31 (12%)	39 (15%)
Transverse colon	19 (7%)	16 (6%)	14 (6%)
Descending colon	19 (7%)	23 (9%)	24 (9%)
Sigmoid colon	71 (28%)	50 (20%)	66 (26%)
Rectosigmoidcolon	22 (9%)	28 (11%)	30 (12%)
Rectum	60 (23%)	36 (14%)	56 (22%)
No finding	-	45 (18%)	-

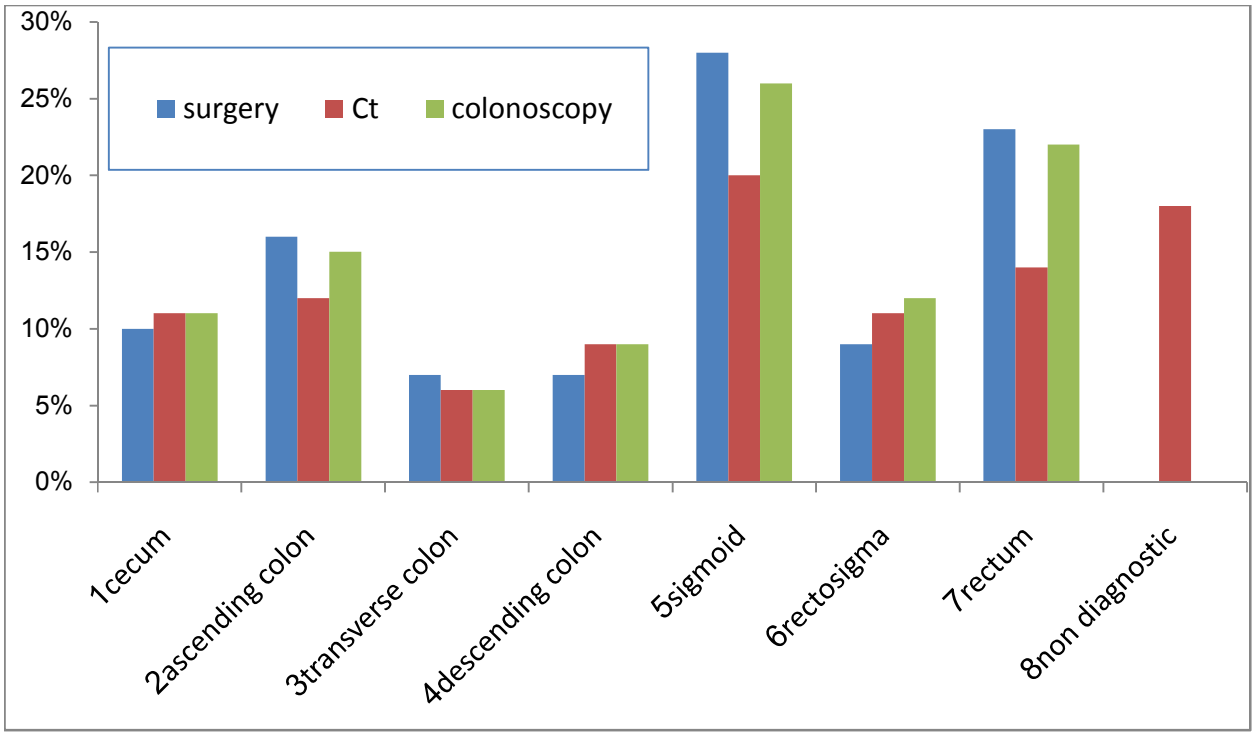

Figure 1. Tumor location along the bowel and the extent of agreement between the preoperative tests and the surgical findings

on the two tests was recorded and compared to the surgical findings.

CRC tumor locations were recorded according to the commonly accepted anatomic segments.

The distribution of tumor location and the extent of agreement between the preoperative tests and the surgical findings with respect to tumor location are presented in Table 1 and Figure 1.

About 60% of the colorectal tumors detected in the study group were located in the distal colon –in the rectum and sigmoid colon. About 1/4 of the tumors were located in the right colon, and about 1/6 – in the transverse colon. (Table 2)

The table was calculated using Cohen's Kappa coefficient method, which measures inter-rater agreement for a certain parameter. Kappa = 1 indicates complete agreement. Complete disagreement is indicated by Kappa = 0.

Complete agreement between surgery and CT was observed in 157 out of 256 patients; i.e., the overall agreement between CT and surgery was 61 % (low Kappa value - 0.08).

Tumors in the hepatic (3) and splenic (6) flexures were accurately diagnosed in these locations by CT in 78% of the cases, a degree of accuracy similar to the accuracy observed in the transverse colon in 8/10 patients – 80%. (Table 3)

The sensitivity of CT was higher for tumors located in the transverse colon (79%) or cecum (76%), and lower for tumors detected in the rectosigmoid colon (46%) and the rectum (55%).

For tumors located in the rectosigmoid colon: A lack of

Table 2. Comparison ofthe accuracy of CT and surgical findings

		Location determined during surgery							Total
		Cecum	Ascending colon	Transverse colon	Descending colon	Sigmoidcolon	Rectosigmoid colon	Rectum	
Location according to CT	Cecum	19	8	0	0	0	0	0	27
	Ascending colon	6	25	0	0	0	0	0	31
	Transverse colon	0	0	15	1	0	0	0	16
	Descending colon	0	0	1	13	7	1	1	23
	Sigmoidcolon	0	0	1	0	42	4	3	50
	Rectosigmoid colon	0	0	0	1	6	10	11	28
	Rectum	0	0	0	0	0	3	33	36
	Non diagnostic	0	7	2	4	16	4	12	45
	Total	25	40	19	19	71	22	60	256

Table 3. Sensitivity of CT scan according to tumor location

	Sensitivity
cecum	76%
ascending colon	63%
transverse colon	79%
	Flexures 78%
descending colon	68%
sigmoid colon	59%
rectosigmoid colon	46%
rectum	55%
non diagnostic	

correlation was observed between CT and surgery in 12 out of 22 patients. In 4 cases, the CT report indicated that the tumor was located in the sigmoid colon, and in 3 cases – that the tumor was located in the rectum. In 4 patients, the CT scan failed to diagnose the tumor.

For tumors located in the rectum: A lack of correlation was observed between the CT and surgery in 27 out of 60 patients. In 11 patients, the CT scan diagnosed the tumor in the rectosigmoid colon, and in 3 patients – in the sigmoid colon. In 12 patients, the CT scan failed to diagnose the tumor.

Overall, the CT scan failed to diagnose the tumor in 45 out of 256 patients (18%).

The table 4 was calculated using Cohen's Kappa coefficient method. Complete agreement between the surgery and the colonoscopy was observed in 208 of the 256 patients; i.e., the overall agreement between the colonoscopy and the surgery was 81% (Kappa value – 0.77). (Table 6)

The sensitivity of colonoscopy was highest for tumors located in the cecum (88%), and lowest for tumors located in the rectosigmoid colon (64%);and was usually higher than the sensitivity of CT forall tumor sites (excluding tumors in the transverse colon). Tumors in the hepatic (3) and splenic (6) flexures were accurately diagnosed at these sites by colonoscopy in 78% (7/9) of the cases, and in the transverse colon in 7/10 patients – 70%.

For tumors detected in the rectosigmoid tumor during surgery – colonoscopy was inaccurate in their localization in 8 out of 22 patients. Of these tumors, 4 were mistakenly defined as rectosigmoid tumors, 3 were detected in the rectum and one was detected in the descending colon.

In general, at the angle connecting the rectum and the sigmoid colon, a shift of the tumor site towards a more distal or more proximal location was observed in the colonoscopy in 36% of the cases.

In rectal tumors, colonoscopy was accurate in 51/60 (85%) cases. In the 9 cases of discrepancy, colonoscopy diagnosed the tumor as located in the sigmoid colon in 3 cases, and in the rectosigmoid colon in 6 cases. That is, in rectal tumors, there was a tendency toward erroneous localization by colonoscopy, manifested by localization of the tumor in a more proximal location in 15% of the cases.

Examination of several parameters which may influence the degree of accuracy of colonoscopy and CT

Table 4. Comparison ofthe accuracy of colonoscopicand surgical findings

		Location determined during surgery							Total
		Cecum	Ascending colon	Transverse colon	Descending colon	Sigmoid colon	Rectosigmoid colon	Rectum	
Location according to colonoscopy	Cecum	22	3	2	0	0	0	0	27
	Ascending colon	3	35	1	0	0	0	0	39
	Transverse colon	0	0	14	0	0	0	0	14
	Descending colon	0	0	2	16	5	1	0	24
	Sigmoid colon	0	0	0	3	56	4	3	66
	Rectosigmoid colon	0	2	0	0	8	14	6	30
	Rectum	0	0	0	0	2	3	51	56
Total		25	40	19	19	71	22	60	256

Table 5. Sensitivity of colonoscopy according to tumor location

	Sensitivity
Cecum	88%
Ascending Colon	87.5%
Transverse Colon	73.7%
Descending Colon	84.2%
Sigmoid Colon	78.9%
Rectosigmoid Colon	63.6%
Rectum	85%

Table 6. Tumor characteristics, such as tumor size, morphology and stage, which may affect the degree of accuracy in tumor localization using the 2 modalities

Colonoscopy				**CT**			
	Agreement N=*208*	**Disagreement N=*48***	**P**		**Agreement N=*157***	**Disagreement N=*99***	**P**
Age	68.0	68.2	P= 0.92	Age	68.9	66.7	P=0.20
Gender (female)	112 (54%)	24 (50%)	P= 0.63	Gender (female)	81 (52%)	55 (56%)	P=0.61
Size of tumor	42.5 mm	42.8 mm	P= 0.93	size of tumor	44.3 mm	40.0 mm	P=0.041
Stage				Stage			
1	*55*(27%)	16 (35%)	P=	1	37 (23%)	37 (37%)	P=0.84
2A	53 (24%)	16 (35%)	0.68	2A	35 (22%)0	34 (34%)	P=0.79
2B	11(5%)	0		2B	8 (3%)	7(7%)	
2C	0	0	P=	2C	5 (2%)	7(7%)	
3A	0	4	0.74	3A	33 (21%)	4 (4%)	
3B	*12* (*5*%)	10 (26%)		3B	12 (6%)	9 (9%)	
3C	8 (4%)	1 (2%)		3C	0	1 (1%)	
4	31 (17%)	0		4	12 (8%)	1 (1%)	
4A	9 (4%)	1 (2%)		4A	9 (4%)	4 (5%)	
4B	6(3%) 8(4%) 15 (7%)	0		4B	1 (1%) 0	0 0	

Table 6. Continue

Obstructing				Obstructing			
Yes	42 (21%)	10 (22%)		Yes	35 (23%)	17 (19%)	
No	155 (79%)	35 (78%)	P= 0.84	No	115 (77%)	75 (81%)	P=0.42
Shape	104 (68%)			Shape			
Circumf.	50 (32%)	20 (59%)	P=	Circumf.	79 (69%)	45 (62%)	P=0.35
polypoid		14 (41%)	0.42	polypoid	36 (31%)	28 (34%)	

Table 7. Complete agreement between surgery, CT and colonoscopy

Total agreement				
		Frequency	**Percent**	
Valid	Fits surgery & colonoscopy	87	34.0	Complete agreement between the 3 modalities was observed in 138 (53.9%) patients
	Fits CT & colonoscopy	12	4.7	
	FALSE	19	7.4	
	TRUE	138	53.9	
	Total	256	100.0	

in tumor localization demonstrated no association between the degree of accuracy and patient's age, gender, tumor morphology, obstruction caused by the tumor or pathological characteristics of the tumor. The only parameter which affected the degree of accuracy was tumor size: tumor size was found to be directly proportional to the level of correlation between CT and surgical findings. None of the parameters was found to significantly affect the extent of the correlation between colonoscopic and surgical findings. (Table 7)

In 138 of the 256 patients (54%), complete agreement in tumor localization by both CT and colonoscopy, as compared to the surgical findings, was observed.

DISCUSSION

Precise tumor localization during the preoperative stage is extremely important. Planning the operative approach and the extent of surgery, as well as decisions regarding adjuvant therapy (such as chemotherapy or radiotherapy for low rectal tumors) are affected by tumor location. Therefore, every effort should be made to localize the tumor as accurately as possible to assist the surgeon or the oncologist in adjusting the appropriate treatment. Nevertheless, we are aware of the limitations typical of the currently available diagnostic modalities.

At present, colonoscopy is the only method for the diagnosis of tumors by direct visualization, and it has the unique advantage of affording the possibility of sampling the tumor tissue for the determination of a final microscopic – pathological diagnosis. However, regarding diagnosis of tumor location, there is no such level of certainty. Determination of the endoscope position in the gastrointestinal system relies on delicate indicators in the anatomical structure of the gastrointestinal tract (such as variability of the spatial appearance of the intestinal folds, or reflection of the "blue" liver and spleen in the flexures). These indicators are not always clear or sufficiently highlighted for the examiner, who remains unable to determine the location of the tumor with certainty. In addition, the depth of penetration of the endoscope into the bowel (its distance from the anus) also contributes to tumor localization. However, the endoscope is a flexible tube, and the gastrointestinal tract is flexible as well. Sometimes the bowel wraps around the endoscope, or vice versa – the endoscope distends the bowel. Therefore, the depth of the device in the colon is not well correlated with its precise anatomical position. Another known challenge is the level of bowel preparation and content emptying, since the details indicating lesion location in a bowel which has been insufficiently cleaned are indistinct and misleading.

These explanations shed light on the possible reasons for erroneous tumor localization, even if the examination is performed at a high level of technical expertise.

CT scans, although considered to be superior or the diagnosis of lesions in parenchymal organs and less effective in the hollow abdominal organs, demonstrate the constant, static shape of the anatomy, with no dynamics of motility. Therefore, it could be supposed that tumor localization would be more accurately performed by CT, which is independent of variable factors.

In this study, colonoscopy was found to be more accurate than CT for tumor localization (81% vs. 61% respectively). Examination of possible variables potentially affecting the level of accuracy, such as tumor shape, pathological grade or obstruction caused by the tumor, the patient's age and gender, demonstrated no effect on the level of tumor localization accuracy. Only the tumor size was found to affect, in a directly proportional manner, the accuracy of CT for tumor localization.

CT accuracy was higher in tumors located in the transverse colon (79%) and the cecum (76%). The sensitivity of colonoscopy was highest for tumors located in the cecum (88%) and the rectum (85%). A tumor located in the cecum, at the end of the colon, can in most cases be diagnosed by both colonoscopy and CT. In contrast, both tests failed to demonstrate a high degree of accuracy for tumors located in the rectosigmoid colon (CT – 46%, colonoscopy – 64%). In the areas of the hepatic and splenic flexures, both tests were similar in terms of their sensitivity, and demonstrated 78% accuracy in tumor localization, although the number of relevant patients was small (only 9 patients).

The rectum is 15 cm long. Overall, colonoscopy was accurate in the localization of rectal tumors (85%). "Errors" towards more proximal sites, which defined the tumor location as in the sigmoid or rectosigmoid colon occurred in 15% of the cases. The rectosigmoid colon, as indicated by its name, is the anatomical junction between the rectum and the sigmoid colon; this is an anatomical angle located 15-20 cm above the anus. Therefore, this region is not clearly defined, and is greatly dependent on examiner's interpretation and understanding of the individual anatomy of the patient. Errors in localization by colonoscopy occurred in 36% of the patients, with a shift towards localization at proximal or distal sites relative to the rectosigmoid angle.

Thus, in the most distal colon, we observed a considerable degree of discrepancy. This is probably related to erroneous interpretation by the examiner, whether due to anatomical variation in the patient, variation in examiner expertise, non-optimal evaluation of distance by colonoscopy or distention of the bowel in the course of the examination. All of the above may explain such discrepancies.

With respect to CT – the results in the rectum and rectosigmoid colon were even less favorable: It must be noted that in 1/5 of the patients, the CT completely failed to diagnose the tumor. Such major inaccuracy of an auxiliary test aimed at diagnosing a colorectal tumor, even if it is located in the distal colon, justifies the use of additional auxiliary tools, such as rectal examination, a proctologist's examination using a rigid proctoscope and rectal ultra sound scan. Of course, this observation supports the conduction of a multidisciplinary discussion with surgeons, radiologists and oncologists regarding any tumor, and especially in the case of a rectal tumor.

The accuracy of colonoscopy and CT has been evaluated in previous studies, but no clear comparison has been performed, and factors potentially affecting the extent of accuracy of each modality have not been examined.

The accuracy of colonoscopy observed in this study is similar to the findings of other studies published in the literature, which report accurate tumor localization by colonoscopy in 88% of cases (Stanciu et al., 2007), and rates of errors ranging between 14% (Cho et al., 2007) to 21% (Piscatelli et al., 2005). Another study reported a higher degree of accuracy for colonoscopy in tumor localization – 96% (Vaziri et al., 2010): the authors concluded that even if erroneous tumor localization occurred in only 4% of the operative patients, mainly in left colon tumors, this error significantly affects the operative approach and its outcomes.

Similarly, based on our experience, the rates of erroneous tumor localization are not very high, but their effect on treatment management is crucial. This is especially evident with the increasing use of minimally invasive surgical procedures and the need for a targeted laparoscopic approach.

CT scans are mainly used for tumor staging: local tumor spread (T stage), lymph node involvement s (N stage) or the existence of metastatic disease (M stage). The CT is also intended to diagnose CRC complications such as perforation, fistula and bowel obstruction (Horton et al., 2000). Based on a previous study, the sensitivity and specificity rates of CT in CRC diagnosis are about 70% and 80%, respectively (Lao et al., 2013). In the case of virtual CT of the colon (CT colonography), the sensitivity and specificity of tumor diagnosis and localization increase to about 95 – 96% (Pickhardt et al., 2011). Our study has found that the accuracy of CT scans is 61%, which is significantly lower than the accuracy of colonoscopies. Furthermore, in 18% of cases, the CT completely failed to diagnose the tumor. These findings indicate that CT is less effective than colonoscopy in the identification of a colon tumor, as well as in accurate tumor localization. We therefore conclude that CT should be used as a complementary modality, especially in cases where CT is highly reliable, such as large tumors and transverse colon tumors, for which the rates of accuracy are highest. It is a common notion that a CT scan is definitive and independent of the specialists who perform and interpret it. However, the capacity of this test for accurate tumor localization may be limited, possibly due to numerous anatomical variations in colon structure, and as found in this study – due to its dependence on tumor dimensions.

A patient with CRC is usually diagnosed and evaluated preoperatively by colonoscopy and abdominal CT. This study indicates that correlation between the two modalities with respect to precise location of the tumor

is expected in only about half of the cases (54%).

Although this study indicates that colonoscopy, despite its limitations, is more accurate than CT for tumor localization, it should be noted that in 19% of the patients, colonoscopy also failed to accurately define the tumor site. This evidence supports the practice of endoscopic tattooing of the tumor site – if possible, in order to minimize the extent of localization error.

The limitations of the study:

Our study has a number of limitations, some of which stem from the fact that it is a retrospective study, a fact which also dictates the sample size that satisfies the study requirements. The study was conducted in quite a large number of patients, yet the number of cases (256) is considered to be a relatively small sample size.

The sample should be expanded in order to draw more accurate conclusions (the results will be more reliable for a larger sample size).

Another limitation results from the fact that colonoscopy is dependent on the performing specialist and the quality of bowel preparation.

CT scan interpretation may also be affected by the expertise of the interpreting specialist and his ability to identify and accurately evaluate tumor location.

CONCLUSION

Colonoscopy provides more accurate information compared to CT with respect to tumor characteristics, including the location of the tumor in the colon, thus contributing to the preoperative decisions and considerations related to planning the optimal oncological treatment.

Although tumor localization by colonoscopy is superior and more accurate, this modality may also be associated with errors and inaccuracies. Precise tumor localization in the distal colon, rectosigmoid colon and rectum is extremely important for choosing the appropriate treatment and making the right decision regarding preoperative chemotherapy and/or radiotherapy. Inaccuracies when using colonoscopy have been demonstrated in these cases as well. These findings may be explained by several factors, among them anatomical variations, the examiner's expertise, and distention of the bowel during the examination, variability in distance interpretation, etc. In any case, whatever the reason for the inaccuracies might be, these findings prove that erroneous tumor localization may occur, and may negatively impact and disrupt the treatment plan. This evidence supports the use of additional techniques, if possible, such as tattooing, the use of rectoscopy and the use of rectal ultrasound, to further verify the tumor location.

At this stage, in the absence of a better modality, colonoscopy should continue to be the modality of choice for preoperative localization of colon tumors. CT scan is greatly important as a complementary examination, mainly for staging and evaluation of disease spread.

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