Effects of a Dietary Approach to Stop Hypertension Eating Plan on Body Mass Index in Patients having Metabolic Syndrome at Kasr Al-Ainy Outpatient Clinic

HEBA G. ELNHASSE, M.Sc.*; GHADA M. KHFAGY, M.D.* and SAHAR A. SHARF, M.D.**

The Departments of Family Medicine* and Clinical & Chemical Pathology**, Faculty of Medicine, Cairo University

Abstract

Background: Diet is an important lifestyle component able to influence the development of chronic diseases. The studies done on the beneficial effects of Dietary Approaches to Stop Hypertension (DASH) diet on Body Mass Index (BMI) in patient having metabolic syndrome (MetS) are limited.

Objectives: To determine the effects of The Dietary Approaches to Stop Hypertension (DASH) versus Usual Dietary Advice (UDA) on Body Mass Index (BMI) in adult patients having MetS.

Methodology: A prospective interventional controlled study conducted on 120 adults diagnosed with MetS using the NCEP/ATPIII. The participants randomly assigned to follow either DASH or UDA for 12 weeks.

Results: DASH and UDA significantly improve weight and BMI in the patient having MetS, but the percent changes due to DASH diet for weight and BMI were 5.8 and 5.6% respectively, while due to UDA were 3.3 and 3.4% respectively.

Conclusion: Weight reduction deserves first priority in obese people having Mets. DASH diet is an ideal and flexible diet that can be considered as a healthy weight losing dietary pattern in patients having MetS.

Key Words: DASH – BMI – Metabolic syndrome.

Introduction

OBESITY is a leading preventable cause of death worldwide; it is one of the most serious public health problems in the 21st century [1]. Obesity accounts for 80% of type II diabetes (T2DM), 35% of ischemic heart disease and 55% of hypertension [2].

Persistent obesity dysregulates metabolic processes including action of insulin on glucose-lipid-free fatty acid metabolism and severely affects processes controlling blood glucose, blood pressure, and lipids. Thus begins a cluster of conditions; dysglycemia, dyslipidemia, hypertension, and procoagulant state, known as the metabolic syndrome [3].

Data suggest that obesity and MetS are immediate precursors of T2DM and cardiovascular disease (CVD) [4].

DASH diet was originally developed to prevent and/or treat high blood pressure; however it is now recommended as an ideal eating pattern for all adults [5]. DASH diet contains high amounts of low-fat dairy products, Ca, K and Mg, all of which have been shown to affect the features of MetS. Moreover, the restricted Na content of the DASH diet leads to lower blood pressure levels. In addition, the greater amounts of dietary fiber, folate, vitamin C, carotenoids, and antioxidants in DASH diet makes it suitable for treating MetS [6].

Most of patients with MetS are overweight or obese, especially upper-body obese [7]. Therefore, basic weight reduction should be recommended in such cases [8]. Intervention studies are needed to determine a specific therapeutic diet for weight reduction in patient with MetS.

Patients and Methods

This is a prospective interventional controlled study conducted on 120 adults with MetS, 60 subjects for each treatment arm (intervention and control) attending the Family Medicine clinic from June 2014 to January 2016. This calculation was based on study power of 80%, confidence interval 95% and effect size 35% using Epi 6 program.
The presence of metabolic syndrome was as-
sessed according to the definition of the Third
Report of the National Cholesterol Education Pro-
gram Expert Panel on Detection, Evaluation, and
Treatment of High Blood Cholesterol in Adults
(The NCEP/ATP III) which included at least three
of the following disorders:
1- Increased waist circumference >102 cm in men
and >88 cm in women.
2- Systolic blood pressure \(\geq 130\) mm Hg or diastolic
blood pressure \(\geq 85\) mm Hg or treatment with
antihypertensive medications.
3- Increased fasting glucose \(\geq 100\) mg/dL or treat-
ment with insulin or antidiabetic medications.
4- High triglyceride levels \(\geq 150\) mg/dL or treat-
tment to decrease triglyceride.
5- Low high-density lipoprotein (HDL) cholesterol
levels <40 mg/dL in men and <50 mg/dL in wom-
en or treatment to increase HDL

All patients \(\geq 35\) years old attending the family
medicine clinics with high blood pressure, fasting
glucose or serum lipid abnormalities, were invited
to participate in the study. Among the invitees who
accepted, subjects met the criteria set by (NCEP/
ATP III) for metabolic syndrome were randomly
divided into two groups: DASH and UDA group
where those with odd numbers were considered as
interventional group and those with even numbers
were considered as control group.

Exclusion criteria: Those who participated in
weight-reduction programs during the previous 6
month. Pregnant and lactating women. Decompens-
ated cardiovascular disease, renal disease and
psychiatric problems. Patients taking any medica-
tion affecting metabolism, blood lipids, and blood
pressure other than their medications as oral con-
traceptives pills, corticosteroids, hormonal replace-
ment therapy, anti-depressive medications, routine
use of non steroidal anti inflammatory drugs or
any vitamin and mineral supplements and antacids
containing magnesium or calcium.

Data collection tools:
Detailed data on socioeconomic status (SES)
was assessed according to the scale developed by
El-Gilany et al. [10], which measured seven domains
including (education and cultural domain, family,
economic, occupational, family possessions, home
sanitation and health care domain) with a total
score of 84.

A score was assigned for each item and the
total score was calculated and SES was classified
into very low, low, middle and high levels depend-
ing on the quartiles of the score calculated.

Behavioral and dietary information including
cigarette smoking, physical activities, and frequen-
cy of intake of various kinds of foods was assessed.

Physical measurements including weight,
height, waist circumference, blood pressure mea-
surement were measured. All measurements were
taken according to standard protocols. BMI was
calculated as body weight in kilograms divided by
the square of height in meters (kg/m\(^2\)). Normal
BMI level was classified as 18.5-24.9 kg/m\(^2\).

The participants were randomly allocated to
follow DASH diet or UDA for 12 weeks. Subjects
were requested to keep their exercises as usual
without any changes.

DASH diet:
DASH dietary pattern is rich in fruit, vegetables,
and low-fat dairy products and lower in saturated
fat, total fat, and cholesterol, containing more
whole grains and fewer refined grains, sweets, and
red meat. The calcium, potassium, and magnesium
of the DASH diet were higher. The DASH diet
contained \(2,400\) mg Na per day (1 teaspoon). The
number of serving units needed for each participant
was decided according to their caloric needs.

The calorie level depends on age and the level
of activities. The chart below used to estimate the
daily calorie needs according the National Heart,
Lung and Blood Institute brief guide to lowering
your blood pressure with DASH [11].

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age (years)</th>
<th>Calories Needed for Sedentary Activity Level</th>
<th>Calories Needed for Moderately Active Activity Level</th>
<th>Calories Needed for Active Activity Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women</td>
<td>31–50</td>
<td>1,800</td>
<td>2,000</td>
<td>2,200</td>
</tr>
<tr>
<td></td>
<td>51+</td>
<td>1,600</td>
<td>1,800</td>
<td>2,000–2,200</td>
</tr>
<tr>
<td>Men</td>
<td>31–50</td>
<td>2,200</td>
<td>2,400–2,600</td>
<td>2,800–3,000</td>
</tr>
<tr>
<td></td>
<td>51+</td>
<td>2,000</td>
<td>2,200–2,400</td>
<td>2,400–2,800</td>
</tr>
</tbody>
</table>
Sedentary means a lifestyle that includes only the usual physical activity associated with typical day-to-day life.

Moderately active means a lifestyle that includes physical activity equivalent to walking about 2.5 to 5 kilometre (km) per day at 5 to 6km per hour, in addition to the usual physical activity associated with typical day-to-day life.

Active means a lifestyle that includes physical activity equivalent to walking more than 5km per day at 5 to 6.5km per hour, in addition to the usual physical activity associated with typical day-to-day life.

After figuring out the daily calorie needs, the researcher advised the participant about the number of servings from each food group according to DASH Eating Plan. Patients were encouraged to eat poultry, fish, nuts, and legumes instead of red meat; low-fat and non fat dairy products instead of full-fat dairy products; vegetables and fruit instead of snacks and desserts high in sugars; breads and pastas made from whole grain instead of white flour; fruit itself rather than fruit juice; and polyunsaturated and monounsaturated cooking oils such as olive, corn, sunflower, canola, soybean, rather than butter.

The dietary goals of the DASH diet as well as a sample of the 1 day menu are explained and given to each participant. The participants also received the required information to use the exchange list of foods.

Usual dietary advice (UDA):

The UDA group was given general oral and written information about healthy food choices based on the Healthy Eating Plate [12].

The main message of the Healthy Eating Plate is to focus on diet quality.

The type of carbohydrate in the diet is more important than the amount of carbohydrate in the diet, because some sources of carbohydrate like vegetables (other than potatoes), fruits, whole grains, and beans are healthier than others.

The Healthy Eating Plate also advises consumers to avoid sugary beverages, a major source of calories usually with little nutritional value.

The Healthy Eating Plate encourages consumers to use healthy oils, and it does not set a maximum on the percentage of calories people should get each day from healthy sources of fat.

Statistical analysis: Data were analyzed using IBM SPSS advanced statistics (Statistical Package for Social Sciences), version 21 (SPSS Inc., Chicago, IL).

Numerical data were described as mean and standard deviation or median and range or median and range. Categorical data were described as numbers and percentages. A $p$-value less than or equal to 0.05 were considered statistically significant.

Results

As shown in Table (1) the mean age of the studied groups was 45±7 years old. Males represented about one third of the studied population while females were about two third.

Two thirds of the studied population was of low and very low socioeconomic statuses (SES) while the remaining one third was of middle and high SES.

There was no statistical significance between DASH and UDA groups before intervention regarding socio-demographic, socio-economic states.

As shown in Table (2) both DASH diet and UDA significantly improve weight and BMI in patients having MetS, but the percent changes due to DASH diet were 5.8 and 5.6% for weight and BMI respectively while due to UDA were 3.3 and 3.4% respectively. There was no statistical significance between the two groups before intervention.
Table (2): The effect of DASH diet versus the UDA on the weight & BMI.

<table>
<thead>
<tr>
<th>Measurements</th>
<th>DASH (Total no=60)</th>
<th>UDA (Total no=60)</th>
<th>( p )-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>94.6±16</td>
<td>83.7±9.8</td>
<td>0.062</td>
</tr>
<tr>
<td>After</td>
<td>89±14.9</td>
<td>81.2±9.7</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Change (%)</td>
<td>–5.8</td>
<td>–3.3</td>
<td>&lt;0.001*</td>
</tr>
</tbody>
</table>

† For comparison of within-group differences.
‡ For comparison of between-groups differences.

Discussion

The mean age of the studied groups was 45 ±7 years old. Males represented about one third of the studied population while females were about two third. There was no statistical significance between DASH and UDA group before intervention regarding socio-demographic, socio-economic status, lifestyle and food frequency intake.

In the present study, we found that adherence to DASH diet had led to significant reduction of weight with percent change of –5.8%, while it was –3.3% in UDA group, which is statistically significant.

These results are matched with the study done by Azadbakht et al. [13], to assess the effect of DASH diet on features of MetS. Three diets were prescribed for 6 months: A control diet (usual diet), a weight-reducing diet (emphasizing healthy food choices), and DASH diet. Relative to control group the mean change (and 95% CI) of weight among men and women following DASH diet for 6 months was (–16 and –14kg) respectively with \( p \).value <0.001. The weight reducing diet resulted also in significant change in weight (–13 and –12kg) among men and women, respectively with \( p \).value <0.05.

Another study done Azadbakht et al. [14] to assess effect of DASH on cardiovascular risk among diabetics, the mean change in weight after 8 weeks in DASH group was –2.0±0.3 while in control group it was –5.0±0.9 with \( p \).value 0.006.

According to the study done by Saneei et al. [15] to assess the effect of DASH versus UDA on features of MetS in adolescents. The mean change of weight after 6 weeks was 0. 16±0.18 in DASH group, while it was –0. 14±0.20 in UDA group which was statistically insignificant.

This difference might be due to the young age group of the study participants, the dietary adherence might not be perfect and also it might be due to the short duration of intervention.

In the present study, the mean BMI of DASH group before the intervention was >35, after the intervention it decreased to be <35, with percent change of –5.6% which was statistically significant, while the mean BMI of the UDA group was >30 and it remained >30 after the intervention, with the percent change of –3.4% which is also statistically significant.

According to Saneei et al. [18] recommendations to follow DASH diet resulted in a significant reduction in BMI, while UDA led to an insignificant decrease.

According to study done by Razavi et al. [16], consumption of DASH diet for 8 weeks among patients with non-alcoholic fatty liver disease (NAFLD) had beneficial effects on weight and BMI with \( p \).values 0.006 and 0.0 1 respectively.

Conclusion:

Weight reduction deserves first priority in individuals with abdominal obesity and the metabolic syndrome. A successful weight reduction needs some changes in lifestyle, including dietary intakes.

Several dietary strategies have been suggested to reduce body weight, including higher vegetable, fruit, fibre, calcium and whole grains intake, and lower fat consumption. DASH eating plan considers all of these recommendations in the frame of a healthy dietary pattern.

References

5- AZADBAKHT L., MIRMIRAN P., ESMAILIZADEH A., et al.: Beneficial effects of a Dietary Approaches to

Effects of a Dietary Approach to Stop Hypertension Eating Plan on Body Mass Index
Stop Hypertension eating plan on features of the metabolic syndrome. Diabetes Care, 28: 2823-2831, 2005.


The Use of Apparent Diffusion Coefficient as a Potential Marker of Rectal Cancer Aggressiveness Compared to Contrast Enhanced MRI in Pre Operative Staging of Rectal Carcinoma

TAMER M. ABD AL-RAHMAN, M.D.*; REDA TABASHY, M.D.*; AHMAD M. MAHMOUD, M.D.** and REDA S. ABD AL-LATIF, M.D.***
The Departments of Diagnostic Radiology* and Surgical Oncology**, National Cancer Institute and The Department of Diagnostic Radiology, Faculty of Medicine***, Cairo University

Abstract

Colorectal cancer ranks third amongst the most frequently diagnosed tumors in the world, after lung cancer and breast cancer.

Objective: To assess the value of MRI and diffusion MRI in characterization of rectal cancer and to investigate the potential use of the quantified ADC values as imaging biomarker of tumor aggressiveness thus helping in the preoperative staging of rectal carcinoma.

Subjects and Methods: 32 patients with rectal cancer were included at this prospective research study at National cancer institute. (19 women, 13 men) from July 2012 to March 2014. Institutional Ethical Committee approval was obtained. All patients gave written consents. All patients were imaged with pelvic MRI examination. A minimum of five pulse sequences (axial T2, T1, and diffusion Wis together with coronal T1 and post contrast dynamic 3D fat sat. T1 WIs gradient study) were performed in all patients. The preoperative radiological staging and post operative pathological results were correlated. Patients with mucinous appearing tumors on the primary staging MRI were excluded.

Results: There was a statistically significant correlation between mean ADCs and different tumor T stage. (p≤0.001) with lower ADC values with higher the T stages.

Conclusion: The key MR sequence for rectal cancer staging is the T2. The addition of IV gadolinium-enhanced sequence did not improve the diagnostic accuracy for prediction of tumor penetration through the rectal wall. ADC values of rectal cancers significantly correlate with prognostic factors including the MRF status and the T and nodal stages.

Key Words: Rectal cancer – High resolution magnetic resonance imaging – Apparent Diffusion Coefficient factor (ADC).

Introduction

COLORECTAL cancer is the third most common cancer worldwide. Around 30-40% of colorectal cancers are located in the rectum, accounting for 5% of malignant tumors, and ranking as the fifth most common cancer in adults [1].

The current trends in the management of rectal cancer point toward a more widespread acceptance of neoadjuvant combined modalities therapies. These create an increasing need for preoperative imaging methods to noninvasively select high risk patients who could benefit from the more aggressive multimodality treatment approaches [2].

The aggressiveness of rectal tumors is expressed by several factors, including T stage, N stage, involvement of the Mesorectal Fascia (MRF), differentiation grade of the tumor, and the presence of lymphangio-vascular invasion [3].

MRI is considered as the modality of choice for rectal cancer staging. The high soft tissue contrast of MRI accurately assesses the extramural tumor extension and relation to Mesorectal Fascia (MRF) and sphincter complex [4].

At present, the use of Diffusion-Weighted Imaging (DWI) incorporated into a standard MR protocol is gradually increasing because of its proven benefit not only for tumor detection/characterization but also for monitoring treatment response [5].

DWI has proven useful for the assessment of tumor cellularity in soft tissue tumors and may be used as a powerful non invasive tool to monitor changes in tumor cellularity [6].
The role of DW imaging in differentiating malignant from benign soft tissue lesions is still evolving when carefully applied, however, this modality has proved helpful in a subset of tumor types [7].

Diffusion weighted imaging measures water diffusion characteristics, which are dependent on multiple factors such as cell density, vascularity, viscosity of extracellular fluid, and cell membrane integrity. By quantifying these properties and expressing them as an Apparent Diffusion Coefficient (ADC), DWI could potentially be used as an imaging biomarker to better select patients with poor prognosis who will truly benefit from a more aggressive neoadjuvant treatment [8].

The value of ADC as a quantitative biomarker in patients with rectal cancer is not clear yet. Data are scarce and most published data on the value of DW-MRI for prediction of response to chemoradiation are conflicting [9].

**Material and Methods**

32 patients with rectal cancer were included in this study (19 female and 13 male), age ranges from 21 to 82 years with the mean age 51 years. The cases were studied at national cancer institute from July 2012 to May 2014. The diagnosis of rectal carcinoma in these patients was established based on their symptomatology, clinical examination, proctoscopy and biopsy.

**Inclusion criteria:**
- Pathologically proven rectal carcinoma.
- Treatment plan by surgical resection with or without neoadjuvant therapy.
- Availability of pathological reports of surgical specimens mentioning tumor differentiation grade.
- Availability of primary staging MRI including DWI.

**Exclusion criteria:**
- Non neoplastic rectal masses.
- Patients with mucinous appearing tumors on the primary staging MRI (completely hyperintense on T2-weighted images without any solid tumor parts) were excluded, because they are known to have low cellular density, exhibiting high ADC values and as such potentially introducing a bias in the study results.

**MRI technique:**

All the patients were imaged on 1.5T MRI machine (1.5-T Philips, Achieva, Release 3.1) with pelvic array coil. The patients were asked to perform rectal wash 2 hours before the MRI examination using a rectal enema. The patient lies in the lateral decubitus at the MRI machine and Foley's catheter was inserted into the anal canal and luminal distention by warm gel (60-100ml) was done. The used sequence protocols for MR imaging of the rectum was standardized. The use of both T2 and T1, diffusion weighted sequences with acquisition of contrast enhanced sequences. At least five pulse sequences (axial T2, T1, and diffusion Wis together with coronal T 1 and post contrast dynamic fat sat. T1 weighted gradient study) were performed in all patients. High resolution T2 Wis. has been used in all cases, with images being obtained using a fast spin echo sequence. The sagittal images were used to plan the axial images as a localizer (the scan plane was perpendicular to the tumor bulk), and coronal images (scan plane angled parallel to the long axis of the rectum); TR/TE, 4000-5000/100; slice thickness 3mm; image gap 0; Echo train length 16; FOV 18-24; 256 X 256 matrix; No. of signal acquired 6; acquisition time 5-7min.

**Axial diffusion sequence:**

DW imaging was performed in the transverse plane with tri-directional diffusion gradients by using b values 0, 300 and 600sec/mm^2 to increase sensitivity to cellular packing. Repetition time (TR)=1.4sec, echo time (TE)=60msec, number of excitations (NEX)=3, matrix 256 X 256 with a field of view 270mm, slice thickness 3mm, slice gap 1-2mm, scan time 1.58min. To ensure that the same areas were measured, regions of interest were copied and pasted from DW images to ADC maps. Apparent diffusion coefficient maps in grayscale were automatically generated at the operating system, using a mono-exponential decay model including all three b-values.

**ADC calculation:**

Mean ADC was calculated from a sample of three round/oval-shaped Regions of Interest (ROIs) that were manually placed within solid tumor parts (as identified as focal masses showing intermediate signal intensity on the anatomical T2-weighted images) of three independent tumor-containing slices. The size and position of the ROIs was chosen to include as much of the solid tumor area as possible.

**T staging interpretations:**
- T1 was staged as if tumor confined to the mucosal layer of rectal wall.
- T2 was staged if there was invasion of the rectal layer up to the muscularis propria with no penetration of the muscularis propria or perirectal fat.
T3 was staged if there was invasion of all rectal layers with perirectal fat infiltration yet without pelvic organ involvement.

T4 was staged if there was invasion of mesorectal fascia and visceral peritoneum or surrounding organ infiltration.

LNs staging interpretations:
- N0 is diagnosed if there was no lymph nodes metastasis.
- N1 is diagnosed if there were metastasis in 1-3 lymph nodes.
- N2 is diagnosed if there were metastasis in 4 or more perirectal lymph nodes.

Mesorectal fascia invasion interpretations:
The mesorectal fascia encircles the rectum and the mesorectal fat, nodes, and lymphatic vessels to form a distinct Anatomic Unit. It is easily identified on axial T2-weighted images as a thin hypointense line. The mesorectal fascia invasion was defined as tumor signal intensity extends through it into adjacent structure or viscus.

Circumferential Resection Margin (CRM) interpretations:
CRM is the distance between the outer margin of tumor and the mesorectal fascia and is critical for surgical planning, potential recurrence after Total Mesorectal Excision (TME). An involved CRM was assumed if the shortest distance from either the extramural tumor extension, a suspected lymph node or a tumor deposit in the mesorectum, to the mesorectal fascia was <1 mm.

This crucial distance of at least 2mm can be predicted with 97% confidence when the distance between a tumor and the mesorectal fascia on MRI is at least 6mm.

Statistical methods:
Data were coded and entered using the statistical package SPSS version 23. Data was summarized using mean, standard deviation, median, minimum and maximum for quantitative variables and frequencies (number of cases) and relative frequencies (percentages) for categorical variables. Comparisons between groups were done using unpaired $t$-test when comparing 2 groups and analysis of variance (ANOVA) with multiple comparisons post hoc test when comparing more than 2 groups. For comparing categorical data, Chi square ($X^2$) test was performed. Exact test was used instead when the expected frequency is less than 5. ROC curve was constructed with area under curve analysis performed to detect best cutoff value of ADC for detection of severity of tumors. $p$-values less than 0.05 were considered as statistically significant.

Results

General criteria:
This study included 32 patients, age ranges from 21 to 82 years with the mean age 51 years. Sex predilection is demonstrated in Fig. (1).

The accuracy, sensitivity, specificity of T2-weighted MR images alone versus combined T2-weighted images plus gadolinium-enhanced T1 weighted MR images for the prediction of rectal wall penetration was assessed with accuracy 96.9%, sensitivity 92.9% and specificity 100% (Table 1). Out of 32 patients in this study, 2 patients were staged as T2 stage by both T2WI and contrast-enhanced T1 WI, 12 patients were staged as T3 by T2WI but 11 patients were staged as T3 by contrast-enhanced T1WI and 18 patients were diagnosed as T4 by T2WI only while 19 patients were staged as T4 by contrast-enhanced T1 WI creating ($p$-value =<0.001).

<table>
<thead>
<tr>
<th>$T$ stage</th>
<th>Count</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2</td>
<td>2</td>
<td>26.2</td>
</tr>
<tr>
<td>T3</td>
<td>11</td>
<td>34.4</td>
</tr>
<tr>
<td>T4</td>
<td>19</td>
<td>59.4</td>
</tr>
</tbody>
</table>

The accuracy, sensitivity, specificity of T2-weighted MR images alone versus combined T2-weighted images plus gadolinium-enhanced T1 weighted MR images for the prediction of tumor extension into mesorectal fascia (Table 2).

Table (1): Contrast enhanced T1 -weighted MR sequences and rectal wall penetration.

T2-weighted MR images vs contrast-enhanced T1 MR images in tumor extension into mesorectal fascia (Table 2).
The Use of ADC as a Potential Marker of Rectal Cancer Aggressiveness Compared

Correlation between ADC and prognostic factors:
The mean tumor ADC for the whole patient population was $0.981 \pm 0.276 \times 10^{-3} \text{ mm}^2/\text{s}$. The difference in ADC values between different groups and their associations with various radiological parameters are outlined in (Table 3).

Discussion
Colorectal cancer is the third cause of cancer worldwide; it accounts for a large number of tumor related deaths and recurrence occurs in about one-third of patients within the first 2 years after surgery [4].

Regarding the use of contrast medium, injection of intravenous contrast (Gadolinium) does not add to the accuracy of staging.

Contrast enhanced T1-weighted MR sequences and rectal wall penetration:
The results of the present study show that the addition of gadolinium-enhanced T1-weighted MR sequences to T2-weighted fast SE MR sequences didn’t significantly improve the diagnostic accuracy for the prediction of tumor penetration through the rectal wall as in all of the 32 patients, both T2WI and contrast-enhanced T1WI gave the same results about T stage except in one case where over staging has occurred in the contrast study creating an accuracy 96.9%, sensitivity 92.9% and specificity 100%. Thus the information given by contrast study was also obtained by T2WI, so contrast study didn’t add to the diagnostic accuracy of T2WI and therefore it can be omitted.

The histopathological results in the 32 patients showed adenocarcinoma in all of them with moderate differentiation, Grade II.

The MRI based findings: 2 patients were staged as T2, 12 as T3 and the remaining 18 were considered to be T4, 4 patients were staged as N0 while 28 had positive nodal disease (N1 and N2). The MRF was free in 12 patients and involved by tumor in the remaining 20.

Table (2): Contrast enhanced T1-weighted MR and tumor extension into the Mesorectal Fascia.

<table>
<thead>
<tr>
<th>Tumor extension in the MRF:</th>
<th>Tumor</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>20</td>
<td>62.5</td>
</tr>
<tr>
<td>No</td>
<td>12</td>
<td>37.5</td>
</tr>
</tbody>
</table>

Table (3): MRI and histopathological findings.

<table>
<thead>
<tr>
<th>Pathology:</th>
<th>Count</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adenocarcinoma, Grade 2</td>
<td>32</td>
<td>100</td>
</tr>
</tbody>
</table>

MRF invasion:

<table>
<thead>
<tr>
<th>MRF invasion:</th>
<th>Count</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>20</td>
<td>62.5</td>
</tr>
<tr>
<td>No</td>
<td>12</td>
<td>37.5</td>
</tr>
</tbody>
</table>

Lymph nodes involvement:

<table>
<thead>
<tr>
<th>Lymph nodes involvement:</th>
<th>Count</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>28</td>
<td>87.5</td>
</tr>
<tr>
<td>No</td>
<td>4</td>
<td>12.5</td>
</tr>
</tbody>
</table>

T Stage:

<table>
<thead>
<tr>
<th>T Stage:</th>
<th>Count</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2</td>
<td>2</td>
<td>6.2</td>
</tr>
<tr>
<td>T3</td>
<td>12</td>
<td>37.5</td>
</tr>
<tr>
<td>T4</td>
<td>18</td>
<td>56.2</td>
</tr>
</tbody>
</table>

Discussion
Colorectal cancer is the third cause of cancer worldwide; it accounts for a large number of tumor related deaths and recurrence occurs in about one-third of patients within the first 2 years after surgery [4].

MRI is currently the only imaging modality for preoperative staging of rectal carcinoma [8].

Regarding the use of contrast medium, injection of intravenous contrast (Gadolinium) does not add to the accuracy of staging.

Contrast enhanced T1-weighted MR sequences and rectal wall penetration:
The results of the present study show that the addition of gadolinium-enhanced T1-weighted MR sequences to T2-weighted fast SE MR sequences didn’t significantly improve the diagnostic accuracy for the prediction of tumor penetration through the rectal wall as in all of the 32 patients, both T2WI and contrast-enhanced T1WI gave the same results about T stage except in one case where over staging has occurred in the contrast study creating an accuracy 96.9%, sensitivity 92.9% and specificity 100%. Thus the information given by contrast study was also obtained by T2WI, so contrast study didn’t add to the diagnostic accuracy of T2WI and therefore it can be omitted.

Correlation between ADC and prognostic factors:
The mean tumor ADC for the whole patient population was $0.981 \pm 0.276 \times 10^{-3} \text{ mm}^2/\text{s}$. The difference in ADC values between different groups and their associations with various radiological parameters are outlined in (Table 3).
Contrast enhanced T1 -weighted MR and tumor extension into mesorectal fascia

Results of our study showed that the addition of gadolinium-enhanced T1-weighted MR imaging does not improve the high accuracy (approximately 90%) of T2-weighted fast SE MR imaging for the evaluation of tumor invasion in the mesorectal fascia as in all of the 32 patients, both T2WI and contrast-enhanced T1WI gave the same results about MRF status creating an accuracy 100%, sensitivity 100% and specificity 100%. Thus the information given by contrast study was also obtained by T2WI, so contrast study didn't add to the diagnostic accuracy of T2WI and therefore it can be omitted thus saving acquisition time and examination costs and avoiding potential allergic reactions.

In a study of 43 patients with rectal cancer, Jhaveri et al. [4] found an accuracy, sensitivity, and specificity of 95%, 67%, and 100%, respectively, for prediction of the circumferential resection margin.

This study supported the idea that gadolinium based contrast material is not essential for the determination of tumor extension into the mesorectal fascia.

Regarding the value of DW-MRI as a potential noninvasive imaging marker of tumor aggressiveness in rectal cancer:

The aggressiveness of rectal tumors is expressed by several factors, including T stage, N stage, and involvement of the Mesorectal Fascia (MRF) which are traditionally assessed by histopathological examination of the surgical specimen.

The goal of the current work was to assess the value of DW-MRI as a potential noninvasive imaging marker of tumor aggressiveness in rectal cancer.

This study was conducted on 32 patients, according to the MRF status, 20 patients were diagnosed as MRF +ve by MRI with the mean ADC of 0.905 X 10^{-3} mm^2/sec while 12 patients were diagnosed as MRF –ve with the mean ADC of 1.109 X 10^{-3} mm^2/sec creating a statistically significant correlation between ADC and MRF status (p-value=0.04). According to T stage, 2 patients were diagnosed as stage T2 with the mean ADC value of 1.750 X 10^{-3} mm^2/sec, 12 patients were diagnosed as stage T3 with the mean ADC value of 0.971 X 10^{-3} mm^2/sec while 18 patients were diagnosed as stage T4, with the mean ADC value of 0.903 X 10^{-3} mm^2/sec creating a statistically significant correlation between ADC and T stage (p-value <0.001). According to the nodal status, 28 patients were diagnosed as LN +ve with the mean ADC value of 0.968 X 10^{-3} mm^2/sec and 4 patients were diagnosed as LN –ve with the mean ADC value of 1.074 X 10^{-3} mm^2/sec creating a non-statistically significant correlation between ADC and N stage (p-value=0.478).

In the current study pretreatment mean ADC was significantly lower for tumors invading MRF or tumors with higher T stage and tumors with positive nodal disease although the latter was not statistically significant. This is an interesting finding as it is proven that both MRF involvement and positive lymph nodes are powerful predictors of a local recurrence and distant metastases. The presence of any correlation between ADC and MRF or T stage or nodal status, therefore, suggests that ADC on itself correlates with prognosis. This could be explained by the fact that ADC values are indirectly derived from a tumor’s cellular microarchitecture and may thus reflect the aggressiveness of the tumor tissue profile.

The results in this study were comparable to many other studies:

The results of a study done by Curvo-Semedo et al., [2] on 50 patients, demonstrated that there was a statistically significant correlation between ADC value and clinical MRF status (p-value=0.013) and nodal status (p-value=0.011) on MR imaging and tumor differentiation grade upon histological examination (p-value=0.025) while there was no significant correlation between ADC and the T stage at primary MRI (p-value=0.064), however we didn't include the histological differentiation grade in our study as all patients in the current study group were grade 2 (moderately differentiated) and that wouldn't be representative of the value of tumor differentiation grade. The results of the current study agreed with him that we found significant correlation between the ADC value and the clinical MRF status (p-value=0.04) and we disagreed with him that in the current study, we found a significant correlation between ADC values and T stage (p-value <0.001) and there is no significant correlation between ADC values and nodal stage at primary MRI (p-value=0.478).

In a study done by Oka et al., [6] on 40 patients, which showed significant correlation between ADC values and tumor differentiation grade (p=0.019) and there was no significant correlation between ADC and T stage (p=0.59) and the presence of MRF invasion (p=0.71) and N stage (p=0.41).
The results of the current study are consistent with their results about the nodal status that we found no significant correlation between ADC values and nodal stage at primary MRI (p-value=0.478) and we were inconsistent with their results about the T stage and MRF status as the current results show significant correlation between the ADC value and the clinical MRF status (p-value =0.04) and T stage (p-value <0.001).

In our study ADC measurements were obtained by measuring three sample ROIs, which may not be fully representative for the overall tumor profile and this approach was chosen because outlining of the whole tumor volume is very time-consuming and difficult to perform in clinical practice.

**Conclusion:**

The most suitable MR sequence for rectal cancer staging is the T2 weighted image sequence as it best depicts the anatomy of the rectal wall.

The addition of IV gadolinium enhanced T1 weighted sequence did not improve the diagnostic accuracy for prediction of tumor penetration through the rectal wall or tumor involvement of the mesorectal fascia.

ADC values of rectal cancers significantly correlate with prognostic factors including the MRF status and the T stage. There is a tendency toward lower ADC values in tumors with involvement of the MRF, node-positive tumors and higher T stage which are the cancers with poorer prognosis. Our study suggests that ADC has the potential to become an imaging biomarker of tumor biological profile.

**References**


الملخص العربي

المقدمة والهدف من الدراسة: يعد سرطان المستقيم هو ثالث أكثر أورام الجهاز الهضمي الخبيثة شيوعًا في العالم وعادة ما يؤدي الارتجاج المبكر للورم بعد الاستئصال الجراحى إلى مرش عضل. وتوقع كيفية تطور سرطان المستقيم يعتمد على عدة عوامل، بعضها يتم تمييزه تقليديا عن طريق الفحص الميكروسكوبى للأنسجة بالعينة الجراحية وتشمل مدى مسافة اختراق الورم لجدار المستقيم وعدد الغدد المفاوية المصابة بالورم وإصابته سرطا المستقيم والتي يمكن تقديرها أيضًا بالتنقيح المغناطيسى قبل التدخل الجراحي.

واستهدفت هذه الدراسة استعراض وتقديم استخدام محمل الانتشار النازحي كخليط محتملة على عين سرطان المستقيم مقارنة بالحنين المغناطيسى التقليدى المعزز بالصبغة.

الموضوع وطريقة البحث: قمنا بإجراء هذه الدراسة على 22 من مرضى سرطان المستقيم بمعدة الأورام القلبية جامعة القاهرة وذلك في الفترة من يوليو 2012 وحتى مارس 2014 بعد إجراء لجنة أخلاقيات البحث العلمى بالمعهد القومي للأورام.

تم تصوير كل المرضى بعد أخذ موافقة كتابية منهم وذلك بعد مساعدة من متابعة تصوير والتي تتضمن زمن تصوير أول وثاني في أوضاع مختلفة وبمود أضافة التصوير بالانتشار وما بعد الصحافة.

تم تقدير المرحلة النازحية بالأشعة في كل المرضى ومقارنتها بنتائج تحليل النسبية ما بعد الجراحة مع استعداد المرضى أصحاب الأورام الخبيثة الجيلابليئة.

نتائج: في دراستنا كانت هناك علاقة إيجابية ذات دلالة إحصائية بين متوسط معدلات الانتشار الموزع ومراحل تدرج الورم المختلفة، ووجد إن معدلات الانتشار نظير كم زادت مرحلة تدرج الورم.

الملاحظات: وقد خصصت نتائج هذه الدراسة إلى أن معدل الانتشار الموزع يعني قيمة أقل كما زادت مسافة اختراق الورم بعد جدار المستقيم وكمية زاد عند الفحص المفاوية المصابة بالورم وعند إصابته سرعا المستقيم ولكن هذه العوامل تدل على توقع أسوأ تطور الورم وبالتالي يمكن استخدام التصوير بالرنين الانتشاري وعلم الانتشار الموزع مع العلم الانتشار الموزع كعوامل من أجل اختيار المرضى الذين سيستبتون من علاج كيابوصأ أو أشعاعية وذلك للكشف المبكر والعلاج القبلي للعلاج.

كما خصصت نتائج البحث إلى أن زمن التصوير الثاني في الرنين المغناطيسى يعني نتائج دقيقة وأن استخدام الصبغة في فحص الرنين المغناطيسى لم يحسن الدقة التشخيصية في تشخيص مدى مسافة اختراق الورم بعد جدار المستقيم أو تشخيص إصابته سرطا المستقيم، وذلك يمكن عدم استخدام الصبغة في فحص الرنين المغناطيسى.