Application value of MRI diffuse weighted imaging combined with PET/CT in the diagnosis of stomach cancer at different stages

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Abstract. Value of MRI diffusion-weighted imaging (MRI DWI) combined with PET/CT in the diagnosis and staging of stomach cancer (SC) was investigated. A retrospective analysis was performed on 160 patients with SC diagnosed by pathological biopsy in The Affiliated Yantai Yuhuangding Hospital of Qingdao University from March 2015 to April 2018. The values of MRI DWI, PET/CT and combined diagnosis in the diagnosis and staging of SC were compared according to the criteria of diagnosis of post-operative pathological or clinical comprehensive evaluation. The sensitivity, specificity and diagnostic coincidence rate of MRI DWI in the diagnosis of SC at stage I-II were 61.05, 64.62 and 62.50%, respectively, which were significantly lower than those of PET/CT (P<0.05). Sensitivity, specificity and diagnostic coincidence rate of MRI DWI in the diagnosis of SC at stage III-IV were lower than those of PET/CT (P<0.05). Sensitivity and diagnostic coincidence rate of MRI DWI combined with PET/CT in the diagnosis of SC at stage I-II were significantly higher than those of MRI DWI or PET/CT alone (P<0.05). Specificity and diagnostic coincidence rate of MRI DWI combined with PET/CT in the diagnosis of SC at stage III-IV were significantly higher than those of MRI DWI or PET/CT alone (P<0.05). PET/CT is superior to MRI DWI in SC staging, whereas the diagnostic efficiency of combined scan is much higher than that of PET/CT or MRI DWI alone. In order to obtain more accurate preoperative staging and to avoid diagnostic exploratory laparotomy, the combination of MRI DWI and PET/CT techniques should be used in the comprehensive analysis of the disease to improve the accuracy of clinical diagnosis.

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Introduction

Stomach cancer (SC), a malignant gastric cancer, originate from the most superficial mucosal epithelial cells of the gastric wall (1). According to the report released by the World Health Organization (WHO), the annual incidence of SC in the world is 14.23/100,000, and more than one million new SC are diagnosed every year in the world. The incidence rate of SC increases significantly with the increase of age, and the peak age range of the disease is 49-80 years, showing a younger trend. Purpose of SC staging is to evaluate the onset of the disease, to facilitate clinicians to summarize and communicate therapeutic effects, to conduct collaborative research on SC, and to develop treatment regimens (2-4). Although pathological diagnosis is the golden standard of clinical staging of SC, some patients can not accept it psychologically and physiologically (5). Due to the development and innovation of medical diagnostic method, the imaging techniques used in clinical diagnosis are constantly upgraded, and the diagnostic coincidence rate is more and more close to pathological diagnosis. At present, M.R.I. diffuse weighted imaging (MRI DWI) and positron emission tomography/computed tomography (PET/CT) are new imaging techniques commonly used in SC clinical staging (6,7).

MRI is an advanced imaging device that has no radiation effects on the human, and can perform local and systemic scans. MRI DWI is a new MR imaging technique fused DWI on the basis of MRI (8). PET/CT, a scanner combined by positron emission tomography and X-ray computed tomography, merges the two imaging techniques perfectly to gain complementary advantages. PET images provide molecular information such as function and metabolism, and CT provides detailed anatomical and pathological information. Pathophysiological and morphological changes of the disease can be reflected by the fusion of these two techniques (9-11). As an advanced examination method at present, the clinical value of PET/CT in the differential diagnosis of tumors, especially SC, cannot be ignored. In addition, it is also non-invasive (12). In this study,

the application value of MRI DWI combined with PET/CT in the diagnosis of SC in different stages was evaluated.

Patients and methods

Inclusion and data collection. One hundred and sixty patients with SC diagnosed by pathological biopsy in The Affiliated Yantai Yuhuangding Hospital of Qingdao University (Yantai, China) from March 2015 to April 2018 were analyzed retrospectively. One hundred and two males and 58 females were included in the study, with an age range of 25-80 years, and a mean age of 50.46±29.54 years (Table I).

Inclusion criteria: i) Only SC patients admitted to The Affiliated Yantai Yuhuangding Hospital of Qingdao University, and tissue samples examined as SC by combined examination of general surgery and pathology were included; and ii) patients who had not received radiotherapy, chemotherapy or other treatment. Exclusion criteria: i) Pregnant women and patients with allergic reactions to contrast agents, claustrophobia and other contraindications.

The study was approved by the Ethics Committee of The Affiliated Yantai Yuhuangding Hospital of Qingdao University. Patients who participated in this research had complete clinical data. Signed informed consents were obtained from the patients or the guardians.

Table I. General clinical data of 160 patients with SC.

Factors	n (%)
Sex	
Male	102 (63.75)
Female	58 (36.25)
Age (years)	
≤50	65 (40.63)
>50	95 (59.37)
Smoking	
Yes	110 (68.75)
No	50 (31.25)
SC histological classification	
Adenocarcinoma	98 (61.25)
Adenosquamous carcinoma	13 (8.13)
Squamous cell carcinoma	34 (21.25)
Carcinoid	15 (9.37)
SC clinical staging	
Stage I	60 (37.50)
Stage II	35 (21.88)
Stage III	40 (25.00)
Stage IV	25 (15.62)
Cell differentiation degree	
Well-differentiated	75 (46.88)
Moderately differentiated	40 (25.00)
Poorly differentiated	45 (28.12)
Lymphatic metastasis	
Yes	55 (34.37)
No	105 (65.63)

Main reagents and instruments. Siemens Verio 3.0T superconducting magnetic resonance instrument was purchased from Siemens AG (Munich, Germany). The bolus injection contrast agent gadopentetate dimeglumine (Gd-DTPA) was purchased from Accdon Company (Waltham, MA, USA). PET/CT imaging agents: ^{18}F-deoxyglucose (^{18}FDG) was purchased from Accdon Company. PET/CT scanner was purchased from Royal Philips Electronics co., Ltd. (Amsterdam, The Netherlands). A 64-slice spiral CT was purchased from Siemens AG.

MRI-DWI examination methods (13). i) The subjects did not eat dinner the day before the examination, and the next day, 250 g of saline was injected from the anus of the subjects before 9 a.m.

ii) Eight channel Torso phased-array body coil was placed in the lower abdomen, and a pad was fixed between the coil and the lower abdomen. The center of the coil was located at 5 cm above the pubic symphysis. Imaging sequence: T1WI-weighted images of SE sagittal position and T2WI-weighted images of CSE sagittal position were generated first; TR: 250-4,000 msec/2,000-3,000 msec; Slice thickness: 3-5 mm, interval: 0.2-0.3 mm, TE: 10-20/100-120 msec; cross-sectional T1WI and T2WI weighted images were generated with the same imaging parameters as above. Then an enhanced examination was performed and 0.2 ml/kg Gd-DTPA was injected via anterior cubital vein at a rate of 2.5 ml/sec. After injection, the conduit was cleaned with 30 ml of saline.

iii) The axial and sagittal images of the lesion were generated by the thin-section images of gradient echo 3D T1-weigted imaging. TE: 7 msec; TR: 15 msec, slice thickness: 2 mm. Diffuse weighted sequence: Axial TR: 4,000 msec; Matrix: 320x224; TE: 62.3-75.6 msec; slice thickness: 6 mm; FOV: 38 cm x 22.8 cm; slice gap: 2 mm; NEX: 6; B value: 1,200 sec/mm^2.

Method of PET/CT examination. i) Establishment of the weight of the patient (the injection measurement of image agent should be controlled according to patient's weight).

ii) Detection of blood glucose in SC patients: Patients with SC should fast for at least 6 h before examination. After 6 h, the venous blood glucose concentration of SC patients was measured to ensure that the blood glucose concentration was <7.8 mmol/l. Too high or too low blood glucose concentration should be handled in time.

iii) Injection of PET/CT imaging agent: ^{18}F-FDG imaging agent was injected into patient's elbow vein when patient's blood glucose concentration was within the normal range. The radiochemical purity should be >95%.

iv) Performing PET/CT examination: Patients needed to empty their urine first and then drink 600 ml purified water before PET/CT examination. CT transmission scanning was performed on the lesions of SC patients first, and the PET was used to scan the largest range of SV lesions, then the decay data of CT was corrected. The fusion images of CT, PET and PET/CT in all directions were then formed.

Criteria of judgement. i) Image analysis of MRI DWI in SC (Table II); and ii) Image analysis of PET/CT in SC staging (Table III).

Table II. Image features of MRI DWI in different stages of SC.

Stages	Image features
I	Lesion is located in mucosa and submucosa
II	Tumor reaches muscular layer
III	The tumor penetrates the muscular layer to the peripheral fat
IV	Other organs are invaded by tumor cells

Table III. Image features of PET/CT in different stages of SC.

Stages	Image features
I	Invading of mucoderm or muscularis mucosae, submucosa
II	Invading of muscularis propria
III	Penetrating subserous connective tissue
IV	Infiltrating the serous membrane or invading adjacent organs

Statistical analysis. SPSS 17.0 (SPSS, Inc., Chicago, IL, USA) software system was used for statistical analysis. The enumeration data were presented as [n (%)]. χ^2 test was used for the univariate analysis of diagnostic accuracy of SC at different stages. P<0.05 was considered to indicate a statistically significant difference.

Results

Diagnostic efficacy of MRI DWI and PET/CT in SC at different stages. i) Diagnostic efficacy of MRI DWI and PET/CT in SC at stage I-II. The sensitivity, specificity and diagnostic accordance rate of MRI DWI in the diagnosis of SC at stage I-II were 61.05, 64.62 and 62.50%, respectively. The sensitivity, specificity and diagnostic accordance rate of PET/CT in the diagnosis of SC at stage I-II were 85.26, 81.54 and 83.75%, respectively. Comparing the data in the two groups, it was showed that the sensitivity, specificity and diagnostic coincidence rate of MRI DWI in the diagnosis of SC at stage I-II were significantly lower than those of PET/CT, and the difference was statistically significant (P<0.05) (Tables IV-VI).

ii) Diagnostic efficacy of MRI DWI and PET/CT in SC at stage III-IV. The sensitivity, specificity and diagnostic accordance rate of MRI DWI in the diagnosis of SC at stage III-IV were 80.00, 71.58 and 75.00%, respectively. The sensitivity, specificity and diagnostic accordance rate of PET/CT in the diagnosis of SC at stage III-IV were 81.54, 85.26 and 83.75%, respectively. Comparing the data in the two groups showed that the sensitivity, specificity and diagnostic coincidence rate of MRI DWI in the diagnosis of SC at stage III-IV were significantly lower than those of PET/CT. The difference of specificity was statistically significant (P<0.05), and there was no significant difference in sensitivity and diagnostic coincidence rate between the two groups (P>0.05) (Tables VII-IX).

Table IV. Diagnostic efficacy of MRI DWI in SC at I-II stage.

	Results of pathological diagnosis		
Groups	I-II stage	Non-I-II stage	Total
MRI DWI diagnosis of I-II stage	58	23	81
MRI DWI diagnosis of non-I-II stage	37	42	79
Total	95	65	160

Table V. Diagnostic efficacy of PET/CT in SC at I-II stage.

	Results of pathological diagnosis		
Groups	I-II stage	Non-I-II stage	Total
PET/CT diagnosis of I-II stage	81	12	93
PET/CT diagnosis of non-I-II stage	14	53	67
Total	95	65	160

Comparison of diagnostic efficacy between MRI DWI combined with PET/CT and MRI DWI or PET/CT alone at different SC stages. The sensitivity, specificity and diagnostic coincidence rate of MRI DWI combined with PET/CT in the diagnosis of SC at stage I-II were 91.58, 80.00 and 86.88%, respectively. The sensitivity and diagnostic coincidence rate of MRI DWI combined with PET/CT in the diagnosis of SC at stage I-II were significantly higher than those of MRI DWI or PET/CT alone, and the differences were statistically significant (P<0.05). While the sensitivity, specificity and diagnostic coincidence rate of MRI DWI combined with PET/CT in the diagnosis of SC at stage III-IV were 80.00, 91.58 and 86.88%, respectively. The sensitivity and diagnostic coincidence rate of MRI DWI combined with PET/CT in the diagnosis of SC at stage III-IV were significantly higher than those of MRI DWI or PET/CT alone, and the differences were statistically significant (P<0.05) (Tables X-XII).

Discussion

Targeted therapy is very important to SC, the key of which is the early detection and accurate staging of SC (14). With the continuous progress and innovation of medical science and technology, the imaging equipment and technology of medical imaging are also making continuous progress. Both MRI DWI and PET/CT are new medical imaging techniques based on traditional MRI, DWI, CT and PET, and have been widely used in early diagnosis, clinical staging and monitoring of curative effect. There is little difference in the economic burden to patients between MRI DWI and PET/CT. Different medical imaging techniques have different imaging principles, and each imaging technique has its own clinical application scope and unique performance. But up to now, there is no definitional judgment that one image

Table VI. Comparison of the diagnostic efficacy of MRI DWI and PET/CT in SC at I-II stage.

Factors	MRI DWI	PET/CT	χ^2	P-value
Sensitivity	61.05% (58/95)	85.26% (81/95)	14.180	<0.001
Specificity	64.62% (42/65)	81.54% (53/65)	4.731	0.030
Diagnostic accordance rate	62.50% (100/160)	83.75% (134/160)	18.380	<0.001

Table VII. Diagnostic efficacy of MRI DWI in SC at III-IV stage.

	Results of pathological diagnosis		
Groups	III-IV stage	Non-III-IV stage	Total
MRI DWI diagnosis of III-IV stage	52	27	79
MRI DWI diagnosis of non-III-IV stage	13	68	81
Total	65	95	160

Table VIII. Diagnostic efficacy of PET/CT in SC at III-IV stage.

	Results of pathological diagnosis		
Groups	III-IV stage	Non-III-IV stage	Total
PET/CT diagnosis of III-IV stage	53	14	67
PET/CT diagnosis of non-III-IV stage	12	81	93
Total	65	95	160

technique can completely replace another (15,16). MRI DWI is an imaging technique developed on the basis of MRI (13), and PET/CT is the most advanced and the best molecular imaging technique for early diagnosis, clinical staging and monitoring of curative effect of tumors and it has been widely used in clinical practice (17). However, there are still some differences in the indications, advantages and disadvantages of these two medical imaging techniques in tumor examination (18). This study explored the value of MRI DWI combined with PET/CT in the diagnosis of SC at different stages.

The diagnostic efficacy of MRI DWI and PET/CT in different SC stages was compared in this study. The results showed that the sensitivity, specificity and diagnostic coincidence rate of MRI DWI in the diagnosis of SC at stage I-II were 61.05, 64.62 and 62.50%, respectively, which were significantly lower than those of PET/CT, and the difference between the two groups was statistically significant (P<0.05). The sensitivity, specificity and diagnostic coincidence rate of MRI DWI in the diagnosis of SC at stage III-IV were lower than those of PET/CT, and the difference of specificity between the two groups was statistically significant (P<0.05). The differences of sensitivity and diagnostic coincidence rate were not statistically significant (P>0.05). Therefore, it is concluded PET/CT is more effective than MRI DWI in the diagnosis of SC clinical staging, and is more suitable for the clinical diagnosis of SC at stage I-IV. There are few reports of MRI DWI and PET/CT in different stages of SC, but from the point of view of Stecco *et al* (19), the diagnostic efficacy of PET/CT in SC is better than that of MRI DWI, and it is more suitable for the clinical diagnosis of SC at stage I-II. By comparing the clinical application value of MRI DWI and PET/CT in tumors, Stecco *et al* found that the clinical diagnostic value of MRI DWI in diagnosis of brain tumors was higher than that in thoracic and abdominal tumors (19). A comparison of the diagnostic efficacy between MRI DWI combined with PET/CT and MRI DWI or PET/CT alone in different SC stages was made in this study. The results showed that the sensitivity and diagnostic coincidence rate of MRI DWI combined with PET/CT in the diagnosis of SC at stage I-II were significantly higher than those of MRI DWI or PET/CT alone, and the difference was statistically significant (P<0.05). While the specificity and diagnostic coincidence rate of MRI DWI combined with PET/CT in the diagnosis of SC at stage III-IV were significantly higher than those of MRI DWI or PET/CT alone, and the difference was statistically significant (P<0.05). Although there is no study on the same experimental design as in this investigation, a large number of studies on MRI DW, PET/CT and their combination are similar to our research results, which corroborate the research viewpoint of this report (19-21).

In this study, because of the small number of subjects there may be contingency in the experimental results.

In conclusion, the diagnostic efficacy of PET/CT at stage I-II was higher than that of MRI DWI. When the two techniques were combined, the diagnostic sensitivity, specificity

Table IX. Comparison of the diagnostic efficacy of MRI DWI and PET/CT in SC at III-IV stage.

Factors	MRI DWI	PET/CT	χ^2	P-value
Sensitivity	80.00% (52/65)	81.54% (53/65)	0.050	0.824
Specificity	71.58% (68/95)	85.26% (81/95)	5.256	0.022
Diagnostic accordance rate	75.00% (120/160)	83.75% (134/160)	3.741	0.053

Table X. Diagnostic efficacy of MRI DWI combined with PET/CT in SC at I-II stage.

	Results of pathological diagnosis		
Groups	I-II stage	Non-I-II stage	Total
Combined diagnosis of I-II stage	87	13	100
Combined diagnosis of non-I-II stage	8	52	60
Total	95	65	160

Table XI. Diagnostic efficacy of MRI DWI combined with PET/CT in SC at III-IV stage.

	Results of pathological diagnosis		
Groups	III-IV stage	Non-III-IV stage	Total
Combined diagnosis of III-IV stage	52	8	60
Combined diagnosis of non-III-IV stage	13	87	100
Total	65	95	160

Table XII. Comparison of diagnostic efficacy between combined diagnosis and MRI DWI or PET/CT alone.

Factors	Combined	MRI DWI	PET/CT	P-value
Stage I-II				
Sensitivity	91.58% (87/95)	61.05% (58/95)	85.26% (81/95)	<0.001
Specificity	80.00% (52/65)	64.62% (42/65)	81.54% (53/65)	0.047
Diagnostic accordance rate	86.88% (139/160)	62.50% (100/160)	83.75% (134/160)	<0.001
Stage III-IV				
Sensitivity	80.00% (52/65)	80.00% (52/65)	81.54% (53/65)	0.968
Specificity	91.58% (87/95)	71.58% (68/95)	85.26% (81/95)	<0.001
Diagnostic accordance rate	86.88% (139/160)	75.00% (120/160)	83.75% (134/160)	0.017

and coincidence rate for different stages of SC were greatly improved. Therefore, it is believed that the MRI DWI combined with PET/CT is of great significance to the future development of medical imaging techniques.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

YS and ZZ wrote the manuscript and were responsible for the MRI-DWI examination and analysis. FL and CH recorded and analyzed the PCT/CT results. YS and CH assisted with the statistical analysis. All authors read and approved the final manuscript.

Ethics approval and consent to participate

The study was approved by the Ethics Committee of The Affiliated Yantai Yuhuangding Hospital of Qingdao University (Yantai, China). Patients who participated in this research had complete clinical data. Signed informed consents were obtained from the patients or the guardians.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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