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Original Article

Role of PET/CT in vertebral lesions in cancer patients

Radiology

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ABSTRACT

Background: Since 18-Fluorodeoxyglucose (18 F-FDG) provides functional information about the body's rate of glucose metabolism, positron emission tomography / Computed tomography (PET/CT) is a good method to detect, stage, and therapeutically monitor many different types of cancer.

Objective: To evaluate the relative merits of 18F-FDG PET, CT, and combined PET/CT for identifying and defining vertebral lesions in cancer patients.

Methodology: A hospital based cross-sectional study was conducted on 40 patients with cancer confirmed by biopsy. During the study period from September 2020 to December 2021, every patient at the Nasser institute hospital for research and treatment - cancer center had CT, and PET/CT scan performed for the whole body.

Results: PET/CT scan showed high sensitivity, specificity and accuracy than CT. 18F-FDG. PET/CT has clinical impact on management in 45.8% of patients by up-staging 8/24 and down-staging 3/24 patients. 18F-FDG PET/CT affects management in (23%) of patients by down-staging 3/13 patients.

Conclusion: 18F-FDG PET/CT may detect osseous metastases. Co-registration of PET and CT images with a combined PET/CT scanner increases sensitivity and specificity.

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Keywords: PET/CT, vertebral lesions, cancer

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INTRODUCTION

Bone scintigraphy (BS) remains the nuclear medicine workhorse for detecting bone metastases in cancer patients, notably those with prostate and breast cancer. For the detection of bone metastases, BS is not only widely accessible, but also cheap and extremely sensitive. Due to enhanced radiotracer absorption occurring in many benign illnesses, including degenerative joint disease, infections, and benign bone malignancies, the great sensitivity comes at the expense of specificity [1].

Radiographs, computed tomography (CT) scans, and magnetic resonant imaging (MRI) can typically tell the difference between benign and malignant intra-osseous lesions. These morphologic imaging techniques are all crucial. The appearance, intra-osseous extent, and internal properties of bone tumors may be learned by radiographs like CT and X-ray. When it comes to detecting soft tissue cancers next to or invading nearby bone, cortical damage, and anomalies in the bone marrow, MRI is the gold standard. Unfortunately, many lesions have a generic morphologic presentation [2].

18-Fluorodeoxyglucose -positron emission tomography (FDG-PET), combined with CT, is a sensitive approach for identifying, staging, and monitoring treatment for a wide range of malignant tumors because it offers functional information about the rate of glucose metabolism in the body [3].

The therapeutic management of oncologic illnesses is profoundly affected by the accuracy with which disease extent is assessed both before and after treatment. A combined PET/CT scanner may increase the sensitivity and specificity of either modality's information by co-registering functional PET scans and anatomic CT images. PET/CT fusion imaging is advantageous since it enables doctors to compare the results of these two imaging techniques. Thus, PET/CT provides better anatomical definition of normal and abnormal uptake observed by FDG-PET [3]. Accordingly, this study was set out to compare the accuracy of 18F-FDG-PET, CT,

and combined PET/CT in detecting and characterizing vertebral lesions in cancer patients.

PATIENTS AND METHODS

This is a hospital based cross-sectional study. Forty individuals with cancer confirmed by biopsies were included in the research. Between September 2020 and December 2021, all patients were scanned using 18F-FDG PET/CT for the whole-body at the cancer center of the Nasser Institute for Medical Research and Treatment. Ethical approval for the research was granted by the relevant institution. All subjects provided written permission after receiving appropriate information.

Inclusion criteria: any cancer patients with suspected lesions in the vertebral column were included in the study.

Exclusion criteria: pregnant and lactating women and patients with increased blood glucose level were excluded from the study.

PET/CT Scanning: patients avoided exercising the day before scanning to reduce the likelihood of an increased uptake from muscular tissue. According to instructions patients had to fast for at least 6 hours before the scan and fill out a questionnaire about their medical history, imaging examinations, allergies, contrast responses, and diabetes status. Before a PET scan, all patients have their blood creatinine and glucose levels checked; the target ranges for both are less than 2 mg/dL and less than 200 mg/dL respectively. When imaging the upper abdomen, patients were drinking 1.5 liters of water as a substitute for oral contrast. After that, 18F-FDG was injected intravenously (3.7 MBq/kg; maximum dosage = 740 MBq) (0.1 mCi/kg; maximum dose = 20 mCi). To reduce physiologic uptake by muscles, post-injection patient activity and speech were restricted. Before getting on the PET/CT table, patients were going to the bathroom. During the CT phase of the test, patients were asked to raise their arms over their heads to reduce beam-hardening artifact. The patients were received an intravenous infusion of 120 mL of a low-osmolarity iodinated contrast agent (Ultravist 300®, Schering, Berlin, Germany). PET/CT imaging with a Biograph was conducted 45-60 minutes after FDG administration (Siemens Biograph TruePoint 64; Siemens Healthcare, Erlangen, Germany).

Whole-body CT (350 mA (eff.), 120 kV, 0.5 second tube rotation, 0.65 pitch, 5-mm sections, 8-mm table feed, 3 mm incremental reconstruction) covered the skull base to the upper thighs. Acquisition time of emission data was 2 minutes per bed position in the two-dimensional mode, and the PET portion was performed over multiple bed positions (five to seven). For each bed position, the axial field of view was around 15 cm, and the in-plane spatial resolution was 4 mm, the same as CT. The whole duration of the test was between 17 and 13 minutes. Patients undergoing CT scans were asked to hold their breath until the scan was completed, whereas those undergoing PET scans were encouraged to breathe shallowly. The gadget provides separate CT and PET data sets were combined with pinpoint accuracy on a conventional computer. PET attenuation correction was used in image reconstruction, and it was also tried without it. All reconstructed pictures, including CT scans, attenuation corrections, and unprocessed raw data, were brought to the syngo platform for integration and visualization (Syngo Multimodality Workplace, Siemens Medical Solutions).

The PET/CT information was divided up into individual PET and CT picture collections. CT and PET scans were analyzed separately by two experts in the field (a radiologist and a nuclear medicine physician). PET and CT images were combined, and then interpreted afterwards. In most cases, PET/CT image interpretation was considered to be the best option. The same criteria were used to the assessment of PET scans and CT scans. Increased 18F-FDG uptake or CT evidence of malignancy were used to determine the severity of the lesions studied. The 18F- FDG avidity of the main tumor as well as its metastases was evaluated using PET scans.

Vertebral lesions were detected on PET imaging and biopsies were taken. There was also a notation of the specific vertebral level and whether or not the body, posterior parts, or both were affected. These findings were combined with the degree of 18F-FDG absorption to provide a malignancy score from 1 (presumably benign) to 3 (certainly malignant) for scintigraphic lesions. Malignant lesions were previously thought to develop in the posterior segment of the body or the pedicles, while benign lesions were thought to develop in the anterior segment, including the facet joints, end plates, as well as the posterior spinous process and regions outside the vertebral body.

Malignancy risk was assessed using a 3-point scale for all CT-detected malignant lesions, regardless of whether they were lytic, sclerotic, mixed lytic-sclerotic, intramedullary, or bone lesions with concomitant soft tissue abnormalities. The paravertebral region has been the site of soft tissue masses such epidural tumors and tumors pressing on neural foramina.

PET/CT was used to review all of the criteria that had been assessed using PET or CT imaging separately. Once malignant tumors showed up on both PET and CT, a diagnosis was made (i.e., In cases when a possible metastatic lesion was detected on both modalities). Large score 2 lesions in several skeletal locations or a PET-detected score 3 lesion were both considered to be highly suspicious of malignancy. If a lesion scored 2 on one modality for malignancy potential but a 1 on another, it was called equivocal.

Statistical analysis

The statistical package for social science (SPSS) version 15 was used for data analysis. Qualitative variables were provided as a frequency distribution and a percentage breakdown. Patients and lesions were studied to calculate the sensitivity, specificity, positive

predictive value (PPV), and negative predictive value (NPV) of 18F-FDG PET and CT for distinguishing malignant from benign bone lesions. The accuracy of the predictions was measured by calculating the area under the Receiver Operating Characteristic (ROC) curve. Results with a p-value of less than 0.05 were considered significant.

RESULTS

We included 40 patients with biopsy-proven malignancy. There were 15 male (37%) and 25 female (63%) patients ranging in age from 21- 70 years (mean ± SD = 43.7 ± 13.6 years) (table 1). Distribution of the lesions assessed by PET/CT revealed that 57% of lesions were malignant and 43% were benign as shown in (figure 1).

Regarding lesions-based analysis, considering equivocal lesions as malignant, 18F-FDG PET identified 291 malignant lesions (290 true positive and 1 false positive). PET showed 95.4% sensitivity, 97.5%specificity, 95.6% accuracy, 99.7% PPV, and 73.6%.NPV. There were 334 cancerous growths, 215 of which were accurately diagnosed and 119 were not. CT scan revealed 70.7% sensitivity, 45.7% specificity, and 60.2% accuracy, 64.4% PPV, and 52.9% NPV. Only 16 out of 215 (7.4%) malignant lesions were found to be associated with compression of the vertebral body. Conversely, 6 compression fractures were found owing to vertebral osteoporosis (benign fractures) (table 2).

Table (1): Age and sex distribution of the studied patients

Variable	n = 40
Age / years	
Range	20 – 70
Mean ± SD	43.7 ± 13.6
Sex	
Males	15 (37%)
Females	25 (63%)

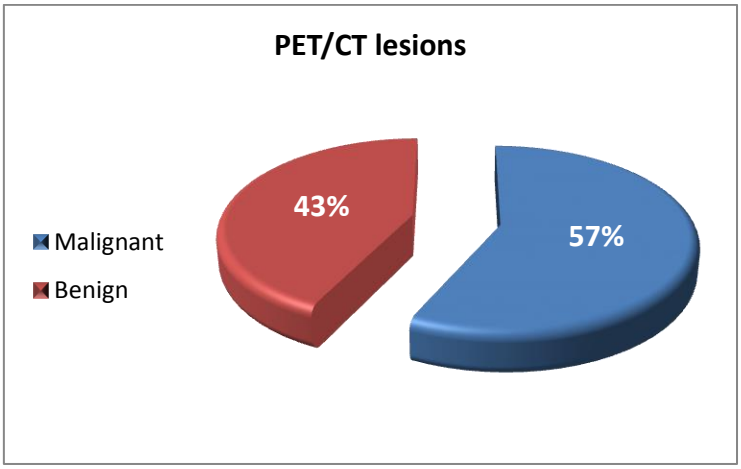

Figure (1): Distribution of the lesions assessed by PET/CT

Table (2): Lesion-based analysis for PET and CT findings

	PET/CT Positive	PET/CT Negative	Total		
PET Positive	290	1	291		
PET Negative	14	39	53		
Total	304	40	344		
	PET/CT Positive	**PET/CT Negative**			
CT Positive	215	119	334		
CT Negative	89	100	189		
	Sensitivity	**Specificity**	**Accuracy**	**PPV**	**NPV**
PET	95.4%	97.5%	95.6%	99.7%	73.6%.
CT	70.7%	45.7%	60.2%	64.4%	52.9%

CT: Computed tomography, **PET**: Positron emission tomography, **PET/CT**: Combined Positron emission tomography / Computed tomography, PPV: Positive predictive value, NPV: Negative predictive value

Regarding patient-based analysis, 18F-FDG PET/CT showed that 28 patients were positive for malignant disease and 12 patients were free from malignancy. PET alone detected 29 patients with malignancy (28

true positive and 1 false positive) and 11 patients without malignancy, whereas CT revealed 31 patients having malignant disease (23 true positive and 8 false positive) and 9 patients with no malignancy (table 3). When comparing 18F-FDG PET and CT separately, the first had a sensitivity of 100%, a specificity of 91.7%, PPV of 96.55%, NPV of 100% and an accuracy of 97.5%, while the latter had a sensitivity of 82.1%, a specificity of 33.3%, PPV of 74.2%, NPV of 44.44% and an accuracy of 67.5% findings.

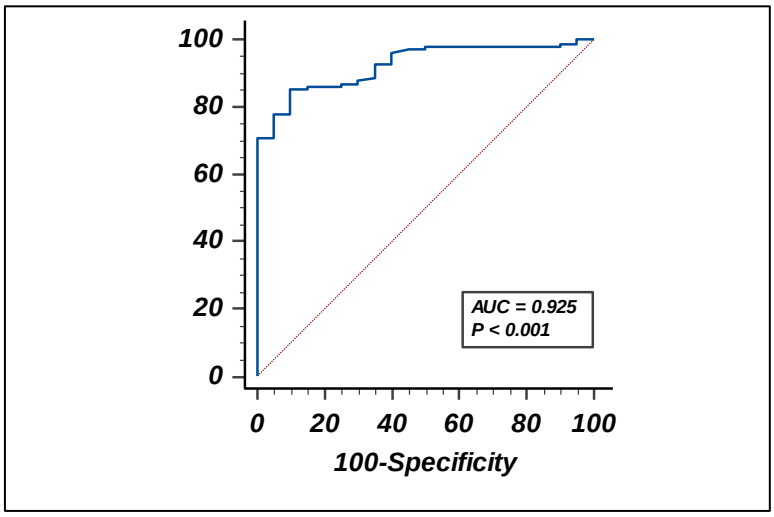

Figure (3): Validity of PET/CT

Table (3): Patient-based analysis for PET and CT findings

	PET/CT Positive	PET/CT Negative	Total		
PET Positive	28	1	29		
PET Negative	0	11	11		
Total	**28**	**12**	**40**		
	PET/CT Positive	**PET/CT Negative**			
CT Positive	23	8	31		
CT Negative	5	4	9		
Total	**28**	**12**	**40**		
	Sensitivity	**Specificity**	**Accuracy**	**PPV**	**NPV**
PET	100%	91.7%,	97.5%	96.55%	100%
CT	82.1%	33.3%.	67.5%	74.2%	44.44%

CT: Computed tomography, **PET**: Positron emission tomography, **PET/CT**: Combined Positron emission tomography / Computed tomography.

Case (1)

A 30 years-old female with a history of left breast cancer. The patient underwent left mastectomy followed by radiation therapy and chemotherapy in 2008. She is under hormonal treatment for 1 year. Last follow up BS revealed disease progression with multiple bone deposits. PET/CT is requested for status evaluation and follow-up. Multiple disseminated metabolically active FDG avid predominantly sclerotic bony lesions are seen involving most of the vertebral column with SUV max of 7.6. Impression of Follow-up PET/CT study for a known case of left breast cancer showing advanced metastatic disease with metabolically active FDG avid disseminated sclerotic osseous deposits (figure 2).

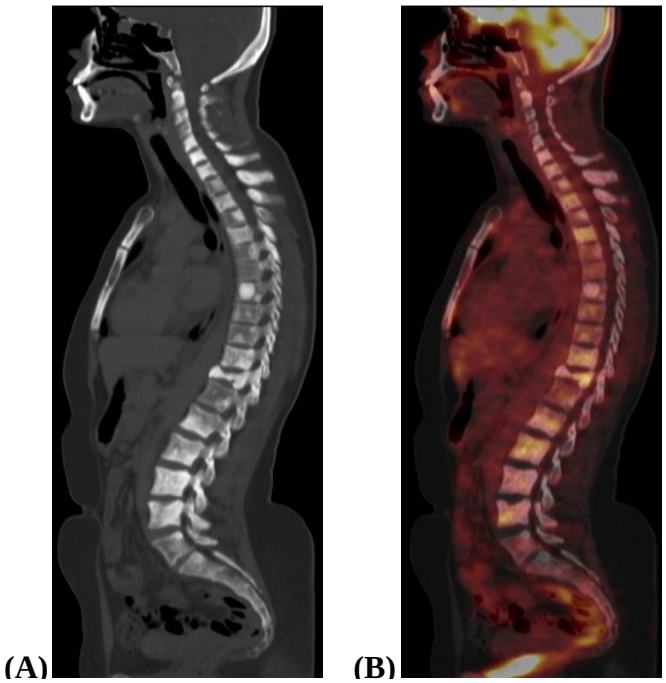

Figure (4): Sagittal CT (A) and fused 18F-FDGPET/CT (B) images of the vertebral column

Case (2)

A 45 years-old female with a history of hepatocellular carcinoma (HCC). The patient underwent radiofrequency ablation 8 months ago. Her main complaint is back pain. BS demonstrated increased tracer fixation at T3-4, L1-2 and L5 vertebral levels, mostly of metastatic nature. Decreased bone density and reduced height with biconcave appearances and fractured vertebral endplates of the T4, L1, L2, L3 and L5 vertebrae with no corresponding significant FDG uptake. PET/CT is requested for characterization of the vertebral lesions. PET/CT study for a known case of hepatocellular carcinoma (HCC) showing advanced osteoporotic changes of the lumbar spine with multilevel vertebral compression fractures. No evidence of metabolically active osseous deposits (figure 3).

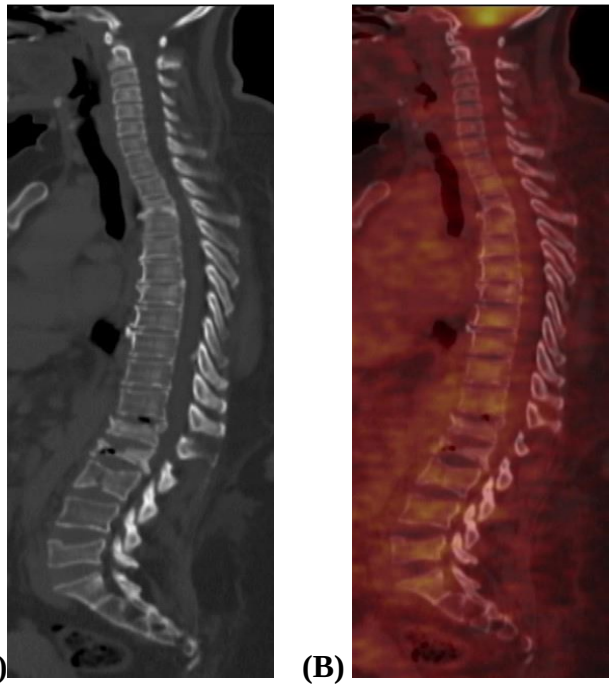

Figure (5): Sagittal CT(A) and fused 18F-FDG PET/CT (B) images of the vertebral column

DISCUSSION

Our findings are consistent with earlier research on 18F-FDG PET/CT for diagnosing malignant spine tumors. PET is more sensitive than CT alone in identifying lesions (98% vs. 74%) but less specific (56% for each modality on a lesion-based analysis)[4]. The results show that 18F-FDG PET/CT is more successful than CT in identifying bone marrow metastases, which might change disease staging for 15% of patients. Bone marrow lesions were detected with PET/CT because of elevated metabolic activity rather than structural alteration. In addition, it allowed for precise tumor viability assessment, which aided in both pre-treatment and post-treatment evaluations [5].

While 18F-FDG uptake in these vertebral foci may vary widely, it is often rather high and is probably linked to the severity of the degenerative process. In certain locations, an increase in 18F-FDG uptake may not always point to the existence of active bone metastases [6]. Previous research has demonstrated that 18F-FDG PET/CT is more sensitive and accurate than traditional imaging (BS and CT) in the identification of bone or bone marrow metastases, and our study clearly verifies those findings [7]. Therefore, evaluation of active bone metastases with 18F- FDG PET/CT is considered to be the gold standard. However, studies aimed at finding bone metastases have revealed that 18F-FDG PET is less useful for diagnosing osteoblastic lesions [8].

While 18F-FDG PET is a more precise imaging technique than others, there is no evidence to suggest that different types of bone metastases are detected at a different rate [9]. The meta-analysis included information from four prospective and two retrospective cohort studies to assess the accuracy of BS and 18F-FDG PET in diagnosing bone metastases in patients with cancer breast[10]. However, 18F-FDG PET may have a significant false positive rate in anomalies with fast glucose metabolism, such as acute osteomyelitis and fractures, while being superior to BS in identifying bone metastases. So, it's important to carefully evaluate photos in light of symptoms and clinical results [11].

PET alone was positive for metastatic illness of the vertebral column in just 1 patient in our data set diagnosed as spondylodiscitis, despite PET/CT findings considered negative (false positive). Intense FDG uptake at the disc space with adjoining vertebral endplates can be mistaken for an active vertebral metastasis or active degenerative process, but the absence of the white cortical vertebral endplates and the disc gap, seen via the unfused sagittal bone window, is diagnostic. Evidence for this conclusion comes from studies that used CT criteria of the PET/CT test to identify cases of spondylodiscitis [12]. In cases when there is low bone marrow infiltration,18F-FDG PET may provide a false negative or equivocal image of bone marrow disease because the diffuse pattern of bone marrow illness might simulate functional bone marrow activity [13].

Furthermore, 18F-FDG PET imaging may show widespread bone marrow involvement as high levels of activity throughout the skeleton. Enhanced FDG absorption may occur for unrelated reasons, such as bone marrow activation by granulocyte-colony stimulating factor (G-CSF), erythropoietin, or B-thalassemia [14].

The small sample size, the wide range of cancer types, and the selection bias favoring individuals with preexisting cancer diagnoses all pose problems for this research.

CONCLUSION

PET/CT is a very effective imaging modality for the evaluation of osseous metastases. The information gained from either PET or CT modalities is improved when PET and CT scan pictures are co-registered. Functional information is provided by PET, whereas anatomical information is provided by CT.

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Conflicts of Interest: The authors declare no conflicts of interest regarding the publication of this paper.

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الملخص العربي

دور المسح البوزيترونى / المقطعي فى امراض الفقرات فى مرضى السرطان

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ملخص البحث

الخلفية: نظرًا لأن 18-فلورودوكسي جلوكوز يوفر معلومات وظيفية حول معدل استقلاب الجلوكوز في الجسم ، فإن التصوير المقطعي بالإشعاع البوزيترونى / التصوير المقطعي المحوسب هو طريقة جيدة للكشف عن العديد من الأنواع المختلفة ومرحلتها ومراقبتها علاجيًا لمرضى السرطان.

الهدف: تقييم المزايا للتصوير المقطعي المحوسب والتصوير المقطعي بالإشعاع البوزيترونى على حدى و التصوير المقطعي بالإشعاع البوزيترونى / التصوير المقطعي المحوسب معا لتحديد وتعريف آفات العمود الفقري في مرضى السرطان.

الطرق: أجريت دراسة مقطعية مستعرضة من المستشفى على 40 مريضًا مصابًا بالسرطان تم تأكيده بواسطة الخزعة. خلال فترة الدراسة من سبتمبر 2020 إلى ديسمبر 2021 ، خضع كل مريض في مستشفى معهد ناصر للأبحاث والعلاج - مركز السرطان للتصوير المقطعي المحوسب ، والتصوير المقطعي بالإشعاع البوزيترونى / المقطعي لكامل الجسم.

النتائج: أظهر التصوير المقطعي بالإشعاع البوزيترونى / التصوير المقطعي المحوسب معا حساسية عالية وخصوصية ودقة من التصوير المقطعي. 18- فلورودوكسي جلوكوز المستخدم في التصوير المقطعي بالإشعاع البوزيترونى / التصوير المقطعي المحوسب معا له تأثير سريري على العلاج في 45.8٪ من المرضى من خلال التدريج الصاعد ضمن 24/8 مريضا و التدريج التنازلي ضمن 24/3 مريضا. يؤثر 18- فلورودوكسي جلوكوز المستخدم في التصوير المقطعي بالإشعاع البوزيترونى / التصوير المقطعي المحوسب مع على العلاج في (23 ٪) من المرضى عن طريق التدريج التنازلي ضمن 13/3 مريضًا.

الاستنتاجات: 18- فلورودوكسي جلوكوز المستخدم في التصوير المقطعي بالإشعاع البوزيترونى / التصوير المقطعي المحوسب قد يكتشف النقائل العظمية. يزيد التسجيل المشترك لصور التصوير المقطعي بالإشعاع البوزيترونى و التصوير المقطعي المحوسب معا من الحساسية والنوعية.

الكلمات المفتاحية: التصوير المقطعي بالإشعاع البوزيترونى / التصوير المقطعي المحوسب، آفات العمود الفقري، السرطان

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