A REVIEW ON FUSION IMAGING IN MAXILLO FACIAL REGION - A DELIBERATION OF UNDENIABLE CREATIVE POWER

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INTRODUCTION

With the advent of many imaging modalities which appraise different parameters of any disease process, fusion of these data has become inevitable for the best understanding of the concerned pathophysiology. Nuclear medicine studies like PET scan primarily assess the functional aspects of the organ and disease process. Similarly, though conventional CT scan and MRI are considered best in delineating the morphological information about the human body and varied disease processes. Hence, fusion of functional and morphological information would probably give us the best information. Fusion imaging is useful in assessing the metastatic lymph nodes involvement and evaluating the treatment outcome.1

Materials and Methods

Review and research articles from 2004 to 2015 on fusion imaging of maxillofacial region were selected from Pubmed data search in English literature, using key words pet, pet/ct, fusion imaging, oral squamous cell carcinoma and SWOT analysis was done.

Results and Discussion

According to Lale Kostakoglu et al, Orazio Schillaci et al 2004, in review 27 and 53 articles respectively, found that the primary advantage of PET-CT fusion technology is the ability to correspond findings from two concurrent imaging modalities in a comprehensive examination that combines anatomic data with functional and metabolic information2, thus helps in diagnosing and treatment planning3. But PET-CT is not helpful in differentiating

a) Inflammatory changes from neoplastic processes in lymph node stations or lymphatic tissues (Waldeyer ring or appendix),

b) Enduring tumor from post-therapy changes immediately after surgery or radiation therapy,

c) Benign thyroid adenoma from thyroid malignancy,

d) Focal physiologic bowel uptake in distinction to large or small bowel malignancies, or

e) Focal physiologic uptake in the uterus while menstruation from uterine cancer2

And the Respiratory motion artefacts, normal uptake will hamper the diagnosis3. To minimise the disadvantages awareness of the pitfalls associated with PET-CT allows accurate image interpretation5.

According to Schoder et al 2004 conducted a study on 68 patients and found that a minimum interval of 3 months after PET/CT (mean, 22 weeks _ 7) FDG PET has become an accepted and extensively used imaging modality for the staging and follow-up of head and neck cancer. PET/CT is more accurate than PET alone in the detection and anatomic localization of head and neck cancer and has the clear potential to affect patient care but in the present study PET images were interpreted first, followed by PET/CT images. Therefore, one might be concerned about a memory or interpretation bias6

ABSTRACT: From advances in X-ray film and cassettes to the launch of computers and digital images, diagnostic imaging has never stopped reinventing its technology to improve patient care. Today, diagnostic imaging is on the cusp of meteoric growth in an arena known as fusion imaging. This technology melds two independent imaging modalities—typically a procedure that demonstrates an organ’s function with one that portray the organ’s anatomy— to produce a diagnostically and clinically superior study.

KEYWORDS: PET/CT, Chemoradiotherapy, Pitfalls.
According to Agarwal et al (2008) in a review of 71 articles found that Proper patient preparation and a complete patient history are needed to accurately interpret the scan and also to avoid the artifacts.

Frank R Miller (2005) conducted a study on 27 patients and found the overall sensitivity of PET was 66.0% and the specificity was 92.9%. The positive predictive equivalent of PET was 88.8% and the negative predictive value was 76.5%. With PET-CT fusion, the percentage of equivocal lesions was reduced by 53%, and the diagnostic accuracy for cancer was increased from 90% to 96%. PET can be a valuable tool to identify the occult primary tumor in patients who present with a metastatic carcinoma in the cervical region. Combined PET/DCT provides the finest anatomic and metabolic in vivo information for the comprehensive management of patients with head and neck cancer.

Birkovich and colleagues (2006) performed PET/CT at 8 to 12 weeks following chemoradiation treatment in 21 patients with various N-stage HNSCC and found a negative predicted value of 92%. Likewise, Nayak and colleagues (2006) performed PET/CT at 8 to 10 weeks later chemoradiation treatment in 30 patients with N2 or N3 HNSCC and found a negative predicted value of 100%.

According to Roh et al., in HNSCC, the accuracy of PET or PET/CT (92%-93%) > CT/MR 85%-86%.

According to Agarwal et al (2008) in a review of 71 articles found that PET/CT had an expanded sensitivity (96%) for detection of nodal disease compared with CT alone (78%). PET/CT is superior to conventional imaging modalities for radiation treatment planning, allowing for improved tumor coverage and sparing of normal tissues. PET was able to recognize a primary tumor with an overall sensitivity and specificity of 88% and 75%, respectively and in evaluating the presence of occult metastasis.

But PET/CT has, however, not been shown to be superior to standard anatomic imaging modalities in assessment of the initial T stage of the primary tumor. The poor spatial resolution of PET imaging united with its failure to detect nodal metastases less than 5 mm in diameter PET/CT is therefore the modality of choice for identifying second primary tumors. Limitations of poor spatial resolution and reduction of anatomic detail on PET imaging are overcome by integrated PET/CT. Initial surveillance with PET/CT should therefore be performed somewhat two months after the conclusion of therapy to decrease the number of false positives.

Murokami R.et al 2008 conducted a study on 20 patients and found that FDG-PET/CT is a useful modality for persistent Gross tumor volume (GTV) assessment. It should not be used as a single modality but relatively to obtain supplemental information for GTV assessment in patients with head-and-neck SCC. But there is currently no gold standard (i.e., pathologic correlation) for GTV assessment and further investigations are required.

In a review of 108 articles Akram Al Ibrahim 2009 found PET/CT significantly better for detection of primary tumor. In staging the use of 18F-FDG PET in head and neck cancer (HNC) compared to CT indicates that PET has a higher sensitivity (87% versus 62%) and specificity (89% versus 73%) for staging cancer. A 3-4 months interval between the end of radiotherapy and evaluation of enduring malignant tissue provides the best specificity and sensitivity for PET.

According to R.M. Subramaniam et al, 2010 in a review of 53 articles found that Radiation-related FDG hyper metabolism may last for 12–16 months after therapy. There is overlay in the Standardized uptake value (SUV) of radiation-related FDG uptake and tumor recurrence, which may mien a problem for interpretation, especially if the PET/CT is performed within 2 months of therapy. PET/CT is more factual when performed at 3–4 months next the completion of radiation therapy than at earlier time points, likely due to reduction in the nonspecific inflammatory. The portrayal of PET/CT is evolving in radiation therapy planning. United PET/DCT provides the best anatomic and metabolic in vivo information for the comprehensive management of patients with head and neck cancer.

According to Ronald Bellaard et al, 2010 in a review of 39 articles found that proper guidelines are followed to provide a minimum standard for the acquisition and interpretation of PET and PET/CT scans with [18F]-fluorodeoxyglucose (FDG).

According to Dandekar et al 2010 in a review of 34 articles found that the utility of 18 FDG-PET for radiotherapy planning has been limited by its lack of spatial resolution and comparatively low specificity. A poor spatial resolution diminishes the ability of PET to locate a target to the degree of accuracy required in precision radiotherapy, such as IMRT. Various methods have been used to boost image registration of PET with a radiotherapy planning CT scan, such as fiducial markers, registration via transmission PET, manual registration, or automatic rigid registration.

Tauzin et al.2010, in a study conducted in 53 patients found that there was significant association between N stage also positive RPLN status. Patients with N2 or greater nodal disease on clinical appearance had higher odds of having positive RPLN status by imaging criteria as compared to those patients who presented with N0-1 disease. The limitations are smaller sample size, results similar to previous studies.

Mohmad El Jhadary et al 2011 in a study (63 patients)-based analysis results in PET/CT sensitivity 92%, specificity 90.9%, positive predictive value 96.2%, negative predictive value 83.3%, and total accuracy 92.1%, in comparison with 74.1%, 27.3%, 71.4%, 30.0%,
and 60.5% for CT, respectively. The inability of the CT to discriminate between the post treatment edema and the local recurrence is the cause of false positive findings. Cistaro et al 2011 conducted a study on 34 patients, in which he performed the PET/CT in both open and closed mouth positions, and stated that the open-mouth scan obtained a preferred score than did the closed-mouth scan when considering the tumor localization, tumor extent, and assessment of adjacent anatomic structures near the clinically evident tumor. The open-mouth scan introduced in this study drive to an increased space between the oral structures. This method grant a much better evaluation of the palate, tongue, and alveolar ridge structures. The most encouraging results obtained in this study are related to the staging of the primary lesion. Despite a reasonably high overall accuracy, the clinical application of 18F-FDG PET/CT may be restrained by the suboptimal sensitivity for small metastases and the relatively huge number of false-positive findings.

Niamh M Long et al 2011, in a review of 50 articles found that in light of the increased reliance of 18F-FDG PET-CT for cancer staging, it is crucial that radiologists and nuclear medicine physicians be familiar with pitfalls in 18F-FDG PET-CT imaging and correlate PET and CT components to avoid misdiagnosis, over staging of disease and unnecessary biopsies.

Singh et al 2013 in a review of 34 articles found that Proper patient preparation and a full patient history are needed to accurately interpret the scan and also to avoid the artifacts. FDG accumulates in the striated laryngeal muscles in proportion to contractile activity during speech leads to false positive findings.

The Waldeyer ring is a common site of head and neck manifestations of extranodal non-Hodgkin lymphoma. Furthermore, primary squamous cell carcinoma of the head and neck may occur within the crypts of the Waldeyer ring. In cases of tonsillar lymphoma, the asymmetric nature of FDG uptake suggests a pathologic process. However, in the absence of CT guidance, malignant processes rising from the lymphatic tissues may be challenging to identify at FDG PET. Low to moderate FDG uptake is noted in the salivary glands, most prominently in the floor of the mouth.

According to Govindarajan et al 2013, Deligkou et al 2013, Fleming et al 2015 in review of 27, 28, 50 articles respectively found that PET/CT is accepted modality for diagnosis, staging, and assessment of tumor response in various types of cancer.

In a study conducted by Krishnatrey M et al. 2013 on 554 patients found that The occurrence of CUP in relative proportion for both males and females showed that the bulk (60%) of the clinical entity of CUP was seen at the supraclavicular lymph nodes, where a considerable proportion of cancers were of the head and neck region.

According to Arthur Varoquaux et al, 2013 conducted a study on 33 patients and found that ADC and SUV values are reproducible and independent biomarkers in HNSCC. Neither SUV nor ADC values were able to predict the histologic grade, although a movement towards higher SUV and lower ADC values was observed in poorly differentiated tumours and Further studies in larger patient populations may address the question of whether the complementary usage of SUV and ADC values could be useful in the diagnosis of primary and recurrent HNSCC.

Arthur Varoquaux et al 2014 conducted a study in 32 patients and found that there was no statistically significant difference among PET/MR and PET/CT regarding rating scores for image quality, fusion aspect, lesion conspicuousness or anatomic location, sum of detected lesions and number of patients with and without malignant lesions. SUVmax and SUVmean measured on PET/MR were significantly lessend than on PET/CT for malignant tumours, metastatic neck nodes, benign lesions, bone marrow, and liver. The main factor affecting the difference between SUVs in malignant lesions was tumour size.

According to Bela et al, 2014 in review of 74 articles found that sensitivity (between 90 and 100 %) and very high negative predictive value (about 97 %) for the detection of tumour recurrence. Inflammation caused by radiotherapy and chemotherapy follow-up PET/ CT should be deferred for at least 2–3 months after chemoradiotherapy to avoid false-positive results, with countless authors advocating 12 weeks after treatment as the optimal timing follow up PET/CT be performed at least 4–6 weeks after surgery after acute inflammation has reduced. FDG is not a tumour specific tracer, Common artefacts seen in the head and neck area are analogous to metallic implants and dental hardware or may occur due to patient motion between the CT and the PET acquisition.

Tantiwongkosi B et al 2014 in a review of 66 articles found that overall PET/CT is more accurate than conventional imaging in detecting metastatic foci. The sensitivity, specificity, PPV and NPV of PET/CT for disclosure of residual primary tumor were 94%, 82%, 75% and 95% respectively. Long term surveillance the NPV of a single PET/CT and double PET/CT (obtained within 6 month period) are 91% and 98% correspondingly. Apposition of perineural escalation due to its high tissue contrast. It is suggested that PET/CT should be performed no early than 2 months after completion of treatment to bypass false positive results; however it may be performed sooner if there is clinically questionable repetitive disease. Dental amalgam artifact is a unique problem for CT imaging in the oral cavity and oropharynx. MRI, however, is prone to motion artefact given it requires more imaging time.

According to Gala Omami et al 2014 in review of 33 articles found that PET/CT can detect and discriminate...
radiation and surgical changes from residual or recurrent tumors because cancer cells hold more FDG for longer periods of time than inflammatory tissues. Initial PET/CT surveillance as early as 8 weeks afterwards completion of therapy may yield highly sensitive and specific information regarding the existence of residual neoplasm, distant metastases, or a second primary tumour (sensitivity, 90.9%; specificity, 93.3%)18

Purender et al 2014 in a review of 21 articles found that a time interval of 12 weeks after completion of radiation therapy is generally recommended. Radiation toxicity can lead to intense inflammatory modifications in the mucosal structures and the soft tissues of the neck that can cause intense FDG accumulation27

Angela et al 2015 in review of 211 articles found that CT/PET performed as early as 2 months post treatment is acceptable without affecting accuracy. Studies have shown that CT/PET scans performed more early have an unacceptably high rate of false-positives and false-negatives25

Yukako et al 2015 conducted a study on 173 patients and a meta analysis of studies comparing research in which both FDG PET and conventional diagnostic tests were performed, found that sensitivity and specificity of FDG PET were 80% and 86%, respectively, and of conventional diagnostic tests were 75% and 79%, proportionally. Scans done > 12 weeks after completion of definitive therapy had moderately higher diagnostic accuracy in this meta-analysis.29

According to Nair et al 2015 conducted a study on 131 patients and found that pet/ct has an overall sensitivity of 95.2% and specificity of 80%. PET-CT scan due to its greater sensitivity and specificity is useful in identifying nodal disease leading to difference in initial staging, which modifies the overall treatment plan affecting survival rates. A realistic evaluation of cost versus benefit needs to be undertaken to analyse the impact of using PET-CT scan as a mode for initial evaluation of HNSCC25

CONCLUSION:

FDG-PET-CT is widely accepted as a modality for evaluating HNC. There is overall increase in the sensitivity and specificity of PET/CT with the help of fiducial markers. Apart from its usage in staging for treatment planning, it can also be used for evaluation of the post therapy status and recurrence after a minimum time period of 12 weeks.

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