Standardized Uptake Value (SUV): Basic Facts

Positron emission tomography and computerized tomography (PET/CT) is the most commonly used hybrid imaging of the current era. This modality has essentially changed the practice of clinical oncology through invaluable sensitive qualitative and quantitative inputs in diagnosis, staging, treatment and response assessment. F-18 labelled deoxyglucose (^{18}FDG) is the most common substrate used for PET/CT due to longer half-life of F-18 (110 minutes) and sensitivity (glucose dependence in most tumors) but relatively low specificity (glucose dependence in infective and inflammatory processes as well). In fact, in some malignancies like lymphoma, lung, melanoma and genitourinary, ^{18}FDG PET/CT has become standard of care.[1]

Qualitative or visual assessment of ^{18}FGD PET/CT based on differential uptake between tumor and normal tissue while hepatic uptake is considered as the reference standard. Various qualitative (visual) criteria have been introduced for treatment response assessment on serial PET/CTs like Deauville 5-point score for lymphomas. Absolute quantitative of glucose in tumor (mol/100 g tissue/min) have also been introduced but is not used in routine clinical practice as it needs dynamic PET acquisition and arterial blood sampling (compartmental and kinetic modelling).[2] Semiquantitative method using standardized uptake value (SUV) of ^{18}FDG is the most commonly used parameter in clinical practice world-wide. The SUV is a dimensionless ratio of activity per unit volume of a region of interest (ROI) to the activity per unit whole body volume and is considered to be a semi-quantitative parameter.

$$\text{SUV} = \frac{\text{Tissue activity (mCi/ml)}}{\text{Injected dose (mCi)/weight (gms)}}$$

Uptake of ^{18}FDG is very low in yellow fat resulting in higher values in tumor and normal tissues in obese patients than in thin individuals. Therefore, correction applied for lean body mass or body surface area (BSA) can eliminate this problem (SUVlean or SUVbsa).

In general, an SUV > 2.5 is considered suggestive of malignancy.[3] Most tumors have an even higher SUV. However, considerable overlap occurs with inflammatory processes like tuberculosis or sarcoidosis where active disease sites show significantly higher SUV values (>2.5). According to one study hypermetabolic benign lesions were found in ^{18}FDG PET/CT in more than 25% of patients with proven or suspected malignancy (inflammation being the most common cause).[4] Therefore, higher SUV is considered as a predictor for malignancy and should not be used as substitute for biopsy. Numerous biological and technical factors could affect SUV values. Common biological factors include body weight (negative correlation), body surface area (negative correlation), blood glucose at time of injection (negative correlation), uptake time (positive correlation in tumor) and respiratory movement. Technical factors include inter-scanner variability (reported 6% variability in SUV calculated by all scanners of same model),[5] image reconstruction parameters (smaller lesion tend to show lower SUV due to partial volume effect), injected dose of 18FDG (reported 10% error in SUV calculation) and use of iodinated oral or intravenous contrast (5.9% variability in SUV between PET with and without contrast).

^{18}FDG activity in a lesion is most commonly reported as SUV_{max} (the value of the most intense pixel in ROI) and allows exclusion of low counts from areas of necrosis or adjacent normal structures. But SUV_{max} has significant variability due to high statistical noise associated with single voxel analysis. An SUV_{mean} is considered more representative as this is an average of all counts in the ROI and eliminates noise from single hot voxel like happens with SUV_{max}. Many experts advocate using an SUVpeak, which is calculated as an average of the counts from a circular volume (often 1 cm) surrounding the hottest

Submitted 11 November 2023, Accepted 12 November 2023

pixel. The SUV_{peak} may more accurately represent maximal tumor metabolism with a higher degree of statistical significance than the SUV_{max}.[9] Richard Wahl et al, introduce SUL_{peak} which is the standardized uptake value corrected for lean body mass in a spherical 1-cm^3 volume of interest.[10]
For therapeutic response evaluation on serial scans,a change in SUV of at least 20% is considered significant. In this regard, all confounding factors that could alter SUV values must be controlled. To mitigate the negative impact, European Association of Nuclear Medicine (EANM) has publish ^{18}FDG PET/CT imaging guidelines to achieve a standardized imaging protocol worldwide. Therefore by adopting a standardized imaging protocol, we could use SUV with high level of confidence in interpreting the therapeutic response on serial studies performed on a same or different scanners.

Conflict of Interest: Declared None.

REFERENCES:

1.Hamdan AJ, Khan AN, Loutfi S, Al-Harbi AS. Guidelines for the role of FDG-PET/CT in lung cancer management. Journal of Infection and Public Health 2012; **5(1):** 35-40.
2. Hirata K, Tamaki N. Quantitative FDG PET Assessment for Oncology Therapy. Cancers (Basel). Feb 2021; **13(4):** 869.
3. Kinahan PE, Fletcher JW. Positron emission tomography-computed tomography standardized uptake values in clinical practice and assessing response to therapy. Semin Ultrasound CT MR. Dec 2010; **31(6):** 496-505.
4. Metser U, Miller E, Lerman H, Even-Sapir E. Benign nonphysiologic lesions with increased 18F-FDG uptake on PET/CT: characterization and incidence. AJR Am J Roentgenol. Nov 2007; **189(5):**1203-10.
5. Scheuermann JS, Saffer JR, Karp JS, Levering AM, Siegel BA. Qualification of PET scanners for use in multicenter cancer clinical trials: The American College of Radiology Imaging Network experience. J Nucl Med 2009; **50:** 1187-93.
6. Geworski L, Knoop BO, de Wit M, Ivancevic V, Bares R, Munz DL. Multicenter comparison of calibration and cross calibration of PET scanners. J Nucl Med 2002; **43:** 635-9.
7. Bunyaviroch T, Turkington T, Wong T, Wilson J, Colsher J, Coleman R. Quantitative effects of contrast enhanced CT attenuation correction on PET SUV measurements. Mol Imaging Biol 2008; **10:** 107-13.
8. Schwartz J, Humm JL, Gonen M, Kalaigian H, Schoder H, Larson SM, et al. Repeatability of SUV measurements in serial PET. Med Phys. (2011); **38:** 2629-38.
9. Julyan, PJ, Taylor JH, Hastings DL, Williams HA, Zweit J. SUVpeak: a new parameter for quantification of uptake in FDG PET. Nuclear Medicine Communications 2004; **25(4):** p 407-9.
10. Jeffrey Leal and Richard Wahl. SUL-PEAK, -MAX and -PAX in PERCIST 1.0: An ROC analysis. J Nucl Med 2012; **53(S1):** 1223-7.
11. Boellaard R, Delgado-Bolton R, Oyen WJ, Giammarile F, Tatsch K, Eschner W, et al. European Association of Nuclear Medicine (EANM). FDG PET/CT: EANM procedure guidelines for tumour imaging: version 2.0. Eur J Nucl Med Mol Imaging. Feb 2015; **42(2):** 328-54.

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