Exa® PACS/RIS

SUV Reference Guide

105-000053A

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SUV reference topics

What is SUV?

The standardized uptake value (SUV) is the concentration of a radiotracer in a user-defined 2D ROI (elliptical or freehand region of interest) on a PET or PET-CT fusion image, as calculated from information stored in the image's DICOM header. There are various methods of calculating SUV, which may differ by facility.

SUV-related programming requirements

When writing code related to calculating SUV or displaying measured results, ensure that the following requirements are met.

- When displaying measured results in the Exa platform, the following information must be included:
  - Calculation method: body weight (**bw**), lean body mass (**lbm**), body surface area (**bsa**) or ideal body weight (**ibw**)
  - Units
  - Minimum, mean, and maximum SUV
- All equations that you use must match those used at the customer's facility.
- An independent evaluation must confirm that the SUV values reported by applications on the Exa platform match those of all PET acquisition devices at the customer's facility, under typical acquisition conditions.
- Final numbers must be rounded to two decimal places.
- Ensure that all data from the DICOM header used in calculations is entered correctly, using the required tags described herein.
- Images must be decay-corrected.

Notes

- Variance in the displayed SUVs between products may appear due to rounding, pixel smoothing, or pixel averaging. This may be exacerbated by post-processing image reconstruction, which also may cause image misalignment. The exacerbation increases with pathology that is larger or occupies a greater number of images.
- The maximal SUV between products will be concordant, but may not correspond to the exact image level. However, this should not affect overall diagnosis.
- The Exa platform does not perform any pixel smoothing or averaging. Calculations are performed using the complete, non-rounded or truncated values in the DICOM header.
- If SUV cannot be computed due to missing or invalid data, check the log for the exact problem.
- Many factors can affect the accuracy of SUV measurements, including image noise/background activity, attenuation correction and patient motion artifacts, partial volume effects, patient size, the timing of the scan post-injection, and user-bias when drawing the ROI.

SUV on PET/CT fusion images

Because PET/CT fusion images are constructed from a volume generated from the PET images, SUV calculation is subject to the interpolation algorithm used in the software. In addition, information used for calculating SUV must be consistent across all PET images. As such, it is possible that SUV can be calculated on a single PET image but not on the fusion image. It is also common that SUV reported on fusion images are slightly different from those on the PET images. If there is ever any doubt about the SUV value reported on a fusion image, you can always draw the same ROI on the closest image in the source PET series.

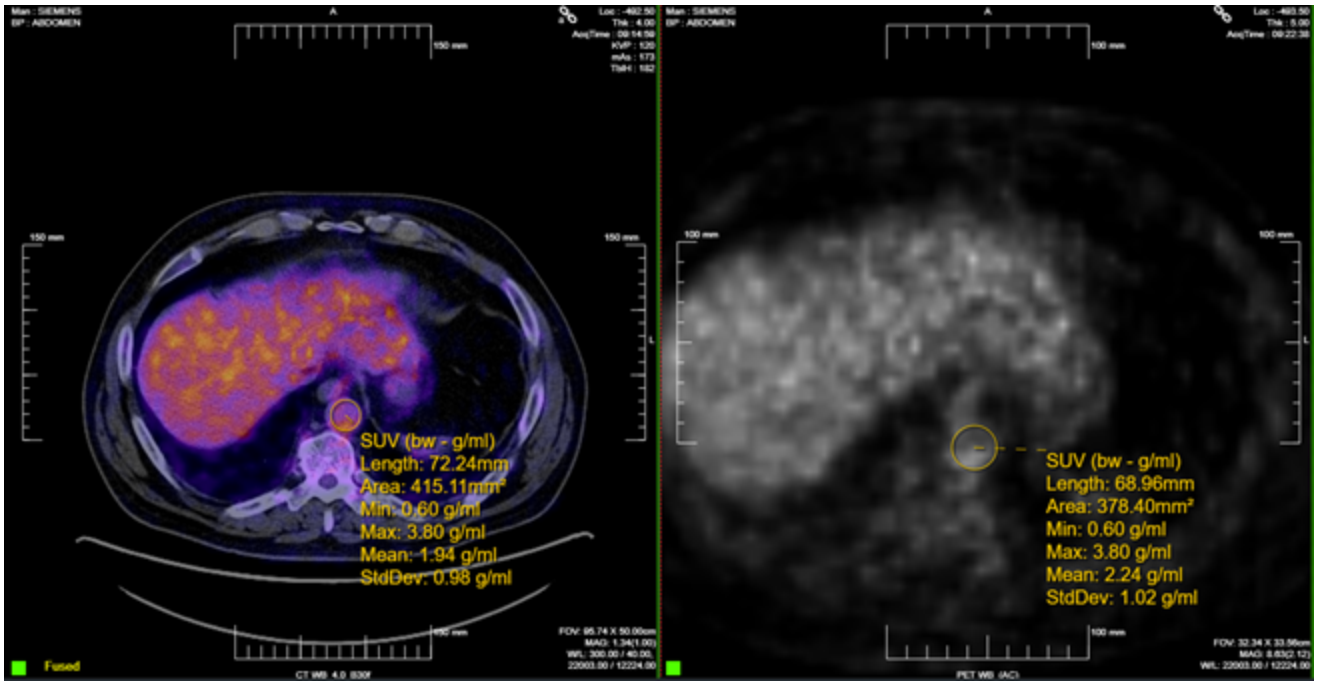

Figure 1: SUV reported on fusion images may be slightly different from those on the PET images.

SUV calculation methods

There are three methods for calculating SUV: lean body mass, body surface area, and decay correction.

Lean Body Mass

Lean body mass is calculated using the James formula for females and the Morgan formula for males:

Male $$1.10 \times W - 120 \times \left(\frac{W}{H}\right)^2$$ [1]

Female $$1.07 \times W - 148 \times \left(\frac{W}{H}\right)^2$$ [2]

W = Patient's weight (kg) **H** = Patient's height (cm)

Body Surface Area

Body surface area is calculated using the Du Bois formula:

$$BSA_{in\ cm^2} = 71.84 \times H^{0.725} \times W^{0.425}$$ [3]

W = Patient's weight (kg) **H** = Patient's height (cm)

Decay Correction

The injected dose used to calculate SUV is corrected for the decay that occurs between the time of injection and the start of the scan using the formula:

$$Decay\ Factor = 2^{\left(\frac{-\Delta t}{T_{1/2}}\right)}$$

T1/2 = Radionuclide half-life in seconds

- If Decay Correction = *START*, Δt = Series Time - Radiopharmaceutical Start Time (for GE post-processed series, series time is retrieved from the private tag)
- If Decay Correction = *ADMIN*, Δt = 0

Note
Exa platform applications do not calculate SUVs from images that are not decay-corrected by the acquisition device.

SUV formulae

Use the following formulas in your calculations.

SUVbw:	Males & females: weight
SUVlbm (James):	Males: 1.10 * weight - 120 * (weight/height)2
SUVlbm (James):	Females: 1.07 * weight - 148 * (weight/height)2
SUVlbm (Janma):	Males: 9.27E3 * weight / (6.68E3 + 216 * weight / (height2))
SUVlbm (Janma):	Females: 9.27E3 * weight / (8.78E3 + 244 * weight / (height2))
SUVbsa:	Males & females: weight0.425 * height0.725 * 0.007184
SUVibw:	Males: 48.0 + 1.06 * (height - 152)
SUVibw:	Females: 45.5 + 0.91 * (height - 152)

Code	Meaning
g/ml{SUVbw}	Standardized uptake value body weight
g/ml{SUVlbm}	Standardized uptake value lean body mass (James)
g/ml{SUVlbm(Janma)}	Standardized uptake value lean body mass (Janma)
cm2/ml{SUVbsa}	Standardized uptake value body surface area
g/ml{SUVibw}	Standardized uptake value ideal body weight

Required tags

Use the following DICOM and vendor-specific tags to calculate SUV, regardless of method.

DICOM header tags

Code			Meaning
(0010,0040)	Patient's Sex	M or F	SUV LBM
(0010,1020)	Patient's Size	Patient's height in meters	SUVLBM, SUV BSA
(0010,1030)	Patient's Weight	Patient's weight in kg	SUV BW, SUVLBM, SUV BSA
(0008,0021)	Series Date		Decay correction
(0008,0031)	Series Time		Decay correction
(0018,1078)	Radiopharmaceutical Start DateTime	Radiopharmaceutical administration time	Decay correction
(0018,1072)	Radiopharmaceutical Start Time	Radiopharmaceutical administration time	Decay correction
(0018,1074)	Radionuclide Total Dose	Radiopharmaceutical dose administered to patient at administration time in becquerels (Bq)	Injected Dose
(0018,1075)	Radionuclide Half Life	Radionuclide half life in seconds	Decay correction
(0054,1001)	Pixel Value Unit (after conversion)		
(0028,1053), (0028,1052)	Rescale Slope, Intercept	Non-zero slope	Converts pixel values to Bq/ml (Activity Concentration)

Vendor-specific tags

Mfg.	Tag	Description	Expected Value	Use
Philips	(7053,xx00)	Private tag for SUV Scale Factor	Non-zero	Only used for Philips images to calculate SUV directly from pixel values
Philips	(7053,xx09)	Private tag for Activity Concentration Scale Factor	Non-zero	Only used for Philips images to convert pixel values to Bq/ml (Activity Concentration)
GE	(0009,xx0D)	Private tag for scan time		Decay correction (for post-processed series only)

References

[1] **James, W. Philip T**. Research on obesity. London: *Her Majesty's Stationery Office*, 1976. ISBN 0114500347.

[2] **Morgan, Denis J. and Bray, Kelly M**. Lean Body Mass as a Predictor of Drug Dosage: Implications for Drug Therapy. *Clinical Pharmacokinetics*. 1994, Vol. 26, 4, pp. 292-307.

[3] **Du Bois, Delafield and Du Bois, Eugene F**. A formula to estimate the approximate surface area if height and weight be known. *Archives of Internal Medicine*. 1916, Vol. 17, 6-2, pp. 863-871.

The formulas for the determination of SUVbw, SUVbsa, SUVlbm (James) and SUVibw are defined in Sugawara et al. Reevaluation of the Standardized Uptake Value for FDG: Variations with Body Weight and Methods for Correction.Radiology, 1999 at http://radiology.rsna.org/content/213/2/521. The Janmahasatian LBM formula is defined in Janmahasatian et al. Quantification of Lean Bodyweight. Clin Pharmacokinet. 2005 Oct 1;44(10):1051–65. at http://dx.doi.org/10.2165/00003088-200544100-00004 and its role in SUVlbm(Janma) calculation is discussed in Tahari et al. Optimum Lean Body Formulation for Correction of Standardized Uptake Value in PET Imaging. Journal of Nuclear Medicine. 2014 Sep 1;55(9):1481–4. at http://jnm.snmjournals.org/content/55/9/1481. The patient size correction factors are summarized here, where weight is in kg and height is in cm: