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| Submission Date | 2014/03/03 |

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| Correction Number CP-1391 |
| Log Summary: Addition of Quantity Descriptors for Perfusion and Tracer Kinetic Modelling |
| Name of Standard |
| PS3.16 2013 |
| Rationale for Correction: |
| <p>The "Abstract Multi-dimensional Image Model Component Semantics" and related units context groups have very limited support for perfusion and tracer kinetic modelling concepts, whether it is performed by CT, PET or MR. Further, many concepts lack meaningful definitions (i.e., are circular).</p> <p>Add definitions where relevant and add new concepts specifically to support CT perfusion, and Dynamic Contrast Enhanced (DCE) MRI, whether it be performed using relaxivity (T1) or susceptibility (T2*) methods.</p> <p>Concepts are added that reflect common usage in specific body parts (e.g., regional "cerebral" blood flow) as well as more general terms that reflect spread of the technique to other body parts (e.g., "regional blood flow" for use in breast, etc.).</p> <p>Tracer kinetic (pharmaco-kinetic) model parameter concepts (like Ktrans) are described generally, without specifying their measurement method or modality, allowing their re-use (e.g., for MR or PET) (and post-coordination by the appropriate technique concepts).</p> <p>These concepts are useful both for encoding of measurements of ROIs in SRs as well as RWVMs in images or as separate objects that describe images.</p> |
| Editor's Notes: |
| <p>Need to decide whether or not to keep the DCE-specific variants of MR signal intensity (i.e., 110804 versus 110816).</p> <p>Need to deal with 110831 "Perfusion", which is probably intended to be Ultrasound-specific, judging by its neighbors.</p> <p>There are duplicates for "Attenuation Coefficient" (112031 and 110851).</p> |
| Correction Wording: |

Amend DICOM PS3.16 - Content Mapping Resource - Context Groups to add the following new Context Groups:

CID cc2c2a T1 Measurement Methods

Type: Extensible

Version: yyyyymmdd

Table CID cc2c2a. T1 Measurement Methods

| Coding Scheme Designator | Code Value | Code Meaning |
|--------------------------|------------|----------------------------|
| DCM | dd2d81 | T1 by Multiple Flip Angles |
| DCM | dd2d82 | T1 by Inversion Recovery |

Note

CID cc2c2b Tracer Kinetic Models

Type: Extensible

Version: yyyyymmdd

Table CID cc2c2b. Tracer Kinetic Models

| Coding Scheme Designator | Code Value | Code Meaning |
|--------------------------|------------|-----------------------------------|
| DCM | dd2d71 | Standard Tofts Model |
| DCM | dd2d72 | Extended Tofts Model |
| DCM | dd2d74 | First Pass Leakage Profile (FPLP) |

Note

CID cc2c2c Perfusion Measurement Methods

Type: Extensible

Version: yyyyymmdd

Table CID cc2c2c. Perfusion Measurement Methods

| Coding Scheme Designator | Code Value | Code Meaning |
|--------------------------|------------|---|
| DCM | dd2d40 | Perfusion analysis by Stable Xenon CT technique |
| DCM | dd2d41 | Perfusion analysis by IV Iodinated Contrast CT technique |
| DCM | dd2d42 | Perfusion analysis by Arterial Spin Labeling MR technique |
| DCM | dd2d43 | Perfusion analysis by Susceptibility MR technique |

Note

CID cc2c2d Arterial Input Function Measurement Methods

Type: Extensible

Version: yyyyymmdd

Table CID cc2c2d. Arterial Input Function Measurement Methods

| Coding Scheme Designator | Code Value | Code Meaning |
|--------------------------|------------|--------------------------------|
| DCM | dd3d01 | AIF Ignored |
| DCM | dd3d02 | Population Averaged AIF |
| DCM | dd3d03 | User-defined AIF ROI |
| DCM | dd3d04 | Automatically Detected AIF ROI |

Note

The anatomic location relevant to the application of any AIF method is not pre-coordinated in concepts in this Context Group. Typically these would be described by the Finding Site of any related measurements in the appropriate template.

CID cc2c2e Bolus Arrival Time Derivation Methods

Type: Extensible

Version: yyyyymmdd

Table CID cc2c2e. Bolus Arrival Time Derivation Methods

| Coding Scheme Designator | Code Value | Code Meaning |
|--------------------------|------------|---|
| DCM | dd3d23 | Temporal Derivative Exceeds Threshold |
| DCM | dd3d20 | Time of Peak Concentration |
| DCM | dd3d22 | Time of Leading Half-Peak Concentration |

Note**CID cc2c2 Quantitative Methods used for Perfusion And Tracer Kinetic Models**

Type: Extensible

Version: yyyyymmdd

Table CID cc2c2. Quantitative Methods used for Perfusion And Tracer Kinetic Models

| Coding Scheme Designator | Code Value | Code Meaning |
|--|------------|--|
| Include CID cc2c2a "T1 Measurement Methods" | | |
| Include CID cc2c2b "Tracer Kinetic Models" | | |
| Include CID cc2c2c "Perfusion Measurement Methods" | | |
| Include CID cc2c2d "Arterial Input Function Measurement Methods" | | |
| Include CID cc2c2e "Bolus Arrival Time Derivation Methods" | | |
| DCM | dd2d73 | Model-free concentration-time quantification |

Note

1. Concepts from this context group may be used in measurement templates to describe the measurement method of measurement on an ROI.

E.g., NUM (dd2d60, DCM, "Ktrans") = 0.0185 /min; (G-C036, SRT, "Measurement Method") = (dd2d72, DCM, "Extended Tofts Model")

CID cc6c1 Tracer Kinetic Model Parameters

Type: Extensible

Version: yyyymmdd

Table CID cc6c1. Tracer Kinetic Model Parameters

| Coding Scheme Designator | Code Value | Code Meaning |
|--------------------------|---------------|---------------|
| <u>DCM</u> | <u>dd2d60</u> | <u>Ktrans</u> |
| <u>DCM</u> | <u>dd2d61</u> | <u>kep</u> |
| <u>DCM</u> | <u>dd2d62</u> | <u>ve</u> |

Note

CID cc6c2 Perfusion Model Parameters

Type: Extensible

Version: yyyymmdd

Table CID cc6c2. Perfusion Model Parameters

| Coding Scheme Designator | Code Value | Code Meaning |
|--------------------------|------------|--------------------------------|
| DCM | 113055 | Regional Cerebral Blood Flow |
| DCM | dd6d01 | Regional Blood Flow |
| DCM | 113056 | Regional Cerebral Blood Volume |
| DCM | dd6d02 | Regional Blood Volume |
| DCM | 113052 | Mean Transit Time |
| DCM | 113069 | Time To Peak |

Note

CID cc6c3 Model-Independent Dynamic Contrast Analysis Parameters

Type: Extensible

Version: yyyymmdd

Table CID cc6c3. Model-Independent Dynamic Contrast Analysis Parameters

| Coding Scheme Designator | Code Value | Code Meaning |
|--------------------------|------------|---|
| DCM | dd2d63 | IAUC |
| DCM | dd2d64 | IAUC60 |
| DCM | dd2d65 | IAUC90 |
| DCM | dd3d20 | Time of Peak Concentration |
| DCM | dd3d22 | Time of Leading Half-Peak Concentration |
| DCM | dd3d21 | Bolus Arrival Time |
| DCM | 113069 | Time To Peak |
| DCM | dd3d24 | Temporal Derivative Threshold |

Note

Amend DICOM PS3.16 - Content Mapping Resource - Context Groups to amend the following context groups to refactor and add new values:

CID 7180 Abstract Multi-dimensional Image Model Component Semantics

Type: Extensible
Version: 20100825yyymmdd

Table CID 7180. Abstract Multi-Dimensional Image Model Component Semantics

| Coding Scheme Designator | Code Value | Code Meaning |
|--------------------------|-------------------|--|
| ... | | |
| DCM | 113063 | T1- Map |
| DCM | 113065 | T2- Map |
| DCM | 113064 | T2*- Map |
| DCM | 113058 | Proton Density- Map |
| DCM | 110800 | Spin Tagging Perfusion MR Signal Intensity |
| ... | ... | ... |
| DCM | 110801 | Contrast Agent Angio MR Signal Intensity |
| DCM | 110802 | Time Of Flight Angio MR Signal Intensity |
| DCM | 110803 | Proton Density Weighted MR Signal Intensity |
| DCM | 110804 | T1 Weighted MR Signal Intensity |
| DCM | 110805 | T2 Weighted MR Signal Intensity |
| DCM | 110806 | T2* Weighted MR Signal Intensity |
| ... | ... | ... |
| DCM | 110807 | Field Map MR Signal Intensity |
| ... | ... | ... |
| DCM | 110816 | T1 Weighted Dynamic Contrast Enhanced MR Signal Intensity |
| DCM | 110817 | T2 Weighted Dynamic Contrast Enhanced MR Signal Intensity |
| DCM | 110818 | T2* Weighted Dynamic Contrast Enhanced MR Signal Intensity |
| DCM | 443055 | Regional Cerebral Blood Flow |
| DCM | 443056 | Regional Cerebral Blood Volume |
| DCM | 443052 | Mean Transit Time |
| DCM | 443069 | Time To Peak map |
| DCM | 110819 | Blood Oxygenation Level |
| ... | ... | ... |
| DCM | 112031 | Attenuation Coefficient |
| DCM | 110827 | Tissue Velocity |
| DCM | 110828 | Flow Velocity |
| SRT | P0-02241 | Power Doppler |
| DCM | 110829 | Flow Variance |
| DCM | 110830 | Elasticity |
| DCM | 110831 | Perfusion |
| ... | ... | ... |
| DCM | 110850 | X-Ray Attenuation |

| Coding Scheme Designator | Code Value | Code Meaning |
|--|------------|-------------------------------|
| DCM | 110851 | X-Ray Attenuation Coefficient |
| DCM | 110852 | MR signal intensity |
| ... | ... | ... |
| <u>Include Section CID cc6c1 "Tracer Kinetic Model Parameters"</u> | | |
| <u>Include Section CID cc6c2 "Perfusion Model Parameters"</u> | | |
| <u>Include Section CID cc6c3 "Model-Independent Dynamic Contrast Analysis Parameters"</u> | | |

CID 7181 Abstract Multi-dimensional Image Model Component Units

Type: Extensible
Version: 20100825yyymmdd

Table CID 7181. Abstract Multi-Dimensional Image Model Component Units

| Coding Scheme Designator | Code Value | Code Meaning |
|--------------------------|--------------------|------------------------------|
| ... | ... | ... |
| UCUM | mmol/kg{WetWeight} | millimoles per kg wet weight |
| UCUM | /min | /min |

Amend DICOM PS3.16 - Content Mapping Resource - Controlled Terminology Definitions to add the following new concepts:

Table D-1. DICOM Controlled Terminology Definitions

| Code Value | Code Meaning | Definition | Notes |
|------------|---|--|-------|
| dd2d40 | Perfusion analysis by Stable Xenon CT technique | Perfusion analysis by Stable Xenon CT technique | |
| dd2d41 | Perfusion analysis by IV Iodinated Contrast CT technique | Perfusion analysis by IV Iodinated Contrast CT technique | |
| dd2d42 | Perfusion analysis by Arterial Spin Labeling MR technique | Perfusion analysis by Arterial Spin Labeling (ASL) MR technique | |
| dd2d43 | Perfusion analysis by Susceptibility MR technique | Perfusion analysis by Susceptibility (T2*) MR technique | |
| dd2d51 | Least Mean Square (LMS) deconvolution | Least Mean Square (LMS) deconvolution | |
| dd2d52 | Singular Value Decomposition (SVD) deconvolution | Singular Value Decomposition (SVD) deconvolution | |
| dd2d60 | Ktrans | <p>K^{trans}, the volume transfer constant of a tracer diffusion kinetic model, specifically the volume transfer constant between blood plasma and extravascular extracellular space (EES)</p> <p>See Tofts et al, "Estimating Kinetic Parameters From Dynamic Contrast-Enhanced T1-Weighted MRI of a Diffusable Tracer: Standardized Quantities and Symbols", Journal of Magnetic Resonance Imaging, vol. 10, pp. 223-232, 1999.</p> | |

| Code Value | Code Meaning | Definition | Notes |
|------------|--|---|-------|
| dd2d61 | kep | k_{ep} , the rate constant between extravascular extracellular space (EES) and blood plasma See Tofts et al, "Estimating Kinetic Parameters From Dynamic Contrast-Enhanced T1-Weighted MRI of a Diffusible Tracer: Standardized Quantities and Symbols", Journal of Magnetic Resonance Imaging, vol. 10, pp. 223–232, 1999. | |
| dd2d62 | ve | v_e , the volume of extravascular extracellular space (EES) per unit volume of tissue See Tofts et al, "Estimating Kinetic Parameters From Dynamic Contrast-Enhanced T1-Weighted MRI of a Diffusible Tracer: Standardized Quantities and Symbols", Journal of Magnetic Resonance Imaging, vol. 10, pp. 223–232, 1999. | |
| dd2d63 | IAUC | The initial area under the contrast agent concentration–time curve | |
| dd2d64 | IAUC60 | The initial area under the contrast agent concentration–time curve at 60 seconds after the onset time | |
| dd2d65 | IAUC90 | The initial area under the contrast agent concentration–time curve at 90 seconds after the onset time | |
| dd2d71 | Standard Tofts Model | A tracer diffusion kinetic model in which the permeability is assumed to be isodirectional. See P. Tofts, "Modeling tracer kinetics in dynamic Gd-DTPA MR imaging", Journal of Magnetic Resonance Imaging, vol. 7, pp. 91–101, 1997. | |
| dd2d72 | Extended Tofts Model | A tracer diffusion kinetic model in which the permeability is not assumed to be isodirectional, and which includes the contribution of tracer in the blood plasma to the total tissue concentration. See P. Tofts, "Modeling tracer kinetics in dynamic Gd-DTPA MR imaging", Journal of Magnetic Resonance Imaging, vol. 7, pp. 91–101, 1997. | |
| dd2d73 | Model-free concentration-time quantification | A semiquantitative analysis of the contrast-enhancement concentration versus time curve that avoids the use of a pharmacokinetic model. E.g., integration to compute the initial area under the curve. | |
| dd2d74 | First Pass Leakage Profile (FPLP) | A tracer diffusion kinetic model that accounts for the tumor leakage profile during the first pass of contrast. See Li, Ka-Loh, Xiao Ping Zhu, John Waterton, and Alan Jackson. "Improved 3D Quantitative Mapping of Blood Volume and Endothelial Permeability in Brain Tumors." Journal of Magnetic Resonance Imaging 12, no. 2 (2000): 347–357. doi:10.1002/1522-2586(200008)12:2<347::AID-JMRI19>3.0.CO;2-7. | |
| dd2d81 | T1 by Multiple Flip Angles | T1 measurement by Multiple Flip Angles (MFA) (variable saturation) method | |
| dd2d82 | T1 by Inversion Recovery | T1 measurement by Inversion Recovery (IR) method | |
| dd3d01 | AIF Ignored | No Arterial Input Function was used. | |
| dd3d02 | Population Averaged AIF | A population-averaged Arterial Input Function. | |
| dd3d03 | User-defined AIF ROI | An Arterial Input Function computed from a user-defined Region of Interest. | |
| dd3d04 | Automatically Detected AIF ROI | An Arterial Input Function computed from an automatically detected Region of Interest. | |

| Code Value | Code Meaning | Definition | Notes |
|------------|---|--|-------|
| dd3d20 | Time of Peak Concentration | The time at which the concentration-time curve achieves its peak for the first time. Used as a concept name for a value or as a method. E.g., used as a method of calculation for BAT. See Shpilfoysel Med Phys 2008. doi: 10.1118/1.1288669 | |
| dd3d21 | Bolus Arrival Time | The nominal time at which arrival of a contrast bolus is detected, which is used as a reference point for subsequent calculations. Used as a concept name for a value or as a method. No specific computational method is implied by this general definition. Abbreviated BAT. | |
| dd3d22 | Time of Leading Half-Peak Concentration | The time at which the concentration-time curve achieves half of its peak density for the first time. Used as a concept name for a value or as a method. E.g., used as a method of calculation for BAT. See Shpilfoysel Med Phys 2008. doi: 10.1118/1.1288669 | |
| dd3d23 | Temporal Derivative Exceeds Threshold | A method of determining BAT that involves computing the temporal derivative of the concentration-time curve and selecting the time when the temporal derivative exceeds a specified threshold. See Shpilfoysel Med Phys 2008. doi: 10.1118/1.1288669 | |
| dd3d24 | Temporal Derivative Threshold | A threshold applied to the temporal derivative of the concentration-time curve. E.g., used to establish BAT. See Shpilfoysel Med Phys 2008. doi: 10.1118/1.1288669 | |
| dd6d01 | Regional Blood Flow | The flow rate of blood perfusing a region as volume per mass per unit of time. | |
| dd6d02 | Regional Blood Volume | The volume of blood perfusing a region as as volume per mass. | |

Amend DICOM PS3.16 - Content Mapping Resource - Controlled Terminology Definitions to make suitable for use both as Abstract Multi-dimensional Image Model Component Semantics and Quantity Descriptor:

Table D-1. DICOM Controlled Terminology Definitions

| Code Value | Code Meaning | Definition | Notes |
|------------|--------------------------------|---|-------|
| ... | ... | ... | ... |
| 112031 | Attenuation Coefficient | A quantitative numerical statement of the relative attenuation of the X-Ray beam at a specified point. Usually expressed in Hounsfield units [referred to as CT Number in Fraser and Pare]. | |
| ... | ... | ... | ... |
| 113052 | Mean Transit Time | The image is derived by calculating mean transit time values The time required for blood to pass through a region of tissue. | |
| ... | ... | ... | ... |
| 113054 | Negative Enhancement Integral | The image is Values are derived by calculating negative enhancement integral values. | |
| 113055 | Regional Cerebral Blood Flow | The image is derived by calculating regional cerebral blood flow values The flow rate of blood perfusing a region of the brain as volume per mass per unit of time. | |
| 113056 | Regional Cerebral Blood Volume | The image is derived by calculating regional cerebral blood volume values The volume of blood perfusing a region of brain as as volume per mass. | |
| ... | ... | ... | ... |
| 113058 | Proton Density- map | The image is Values are derived by calculating proton density values. | |
| 113059 | Signal Change- Map | The image is Values are derived by calculating signal change values. | |
| ... | ... | ... | ... |

| Code Value | Code Meaning | Definition | Notes |
|------------|--|--|-------|
| 113063 | T1-Map | The image is <u>Values are</u> derived by calculating T1 values. | |
| 113064 | T2*-Map | The image is <u>Values are</u> derived by calculating T2* values. | |
| 113065 | T2-Map | The image is <u>Values are</u> derived by calculating T2 values. | |
| 113066 | Time Course of Signal | The image is <u>Values are</u> derived by calculating values based on the time course of signal. | |
| ... | ... | ... | ... |
| 113069 | Time To Peak-map | The image is derived by calculating values based on the time to peak <u>The time from the start of the contrast agent injection to the maximum enhancement value .</u> | |
| ... | ... | ... | ... |
| 110800 | Spin Tagging Perfusion MR Signal Intensity | Signal intensity of a Spin tagging Perfusion MR image. Spin tagging is a technique for the measurement of blood perfusion, based on magnetically labeled arterial blood water as an endogenous tracer. | |
| 110801 | Contrast Agent Angio MR Signal Intensity | Signal intensity of a Contrast Agent Angio MR image. | |
| 110802 | Time Of Flight Angio MR Signal Intensity | Signal intensity of a Time-of-flight (TOF) MR image. Time-of-flight (TOF) is based on the phenomenon of flow-related enhancement of spins entering into an imaging slice. As a result of being unsaturated, these spins give more signal than surrounding stationary spins. | |
| 110803 | Proton Density Weighted MR Signal Intensity | Signal intensity of a Proton Density Weighted MR image. All MR images have intensity proportional to proton density. Images with very little T1 or T2 weighting are called 'PD-weighted'. | |
| 110804 | T1 Weighted MR Signal Intensity | Signal intensity of T1 Weighted MR image. A T1 Weighted MR image is created typically by using short TE and TR times. | |
| 110805 | T2 Weighted MR Signal Intensity | Signal intensity of a T2 Weighted MR image. T2 Weighted image contrast state is approached by imaging with a TR long compared to tissue T1 (to reduce T1 contribution to image contrast) and a TE between the longest and shortest tissue T2s of interest. | |
| 110806 | T2* Weighted MR Signal Intensity | Signal intensity of a T2* Weighted MR image. The T2* phenomenon results from molecular interactions (spin spin relaxation) and local magnetic field non-uniformities, which cause the protons to precess at slightly different frequencies. | |
| 110807 | Field Map MR Signal Intensity | Signal intensity of a Field Map MR image. A Field Map MR image provides a direct measure of the B_0 inhomogeneity at each point in the image. | |
| ... | ... | ... | ... |
| 110816 | T1 Weighted Dynamic Contrast Enhanced MR Signal Intensity | Signal intensity of a T1 Weighted Dynamic Contrast Enhanced MR image. A T1 Weighted Dynamic Contrast Enhanced MR image reflects the dynamics of diffusion of the exogenous contrast media from the blood pool into the extra vascular extracellular space (EES) of the brain at a rate determined by the blood flow to the tissue, the permeability of the Brain Blood Barrier (BBB), and the surface area of the perfusing vessels. | |
| 110817 | T2 Weighted Dynamic Contrast Enhanced MR Signal Intensity | Signal intensity of a T2 Weighted Dynamic Contrast Enhanced MR image. A T2 Weighted Dynamic Contrast Enhanced MR image reflects the T2 of tissue decrease as the Gd contrast agent bolus passes through the brain. | |
| 110818 | T2* Weighted Dynamic Contrast Enhanced MR Signal Intensity | Signal intensity of a T2* Weighted Dynamic Contrast Enhanced MR image. A T2* Weighted Dynamic Contrast Enhanced MR image reflects the T2* of tissue decrease as the Gd contrast agent bolus passes through the brain. | |

| Code Value | Code Meaning | Definition | Notes |
|------------|-------------------------------|---|-------|
| 110819 | Blood Oxygenation Level | Signal intensity of a Blood Oxygenation Level image. BOLD imaging is sensitive to blood oxygenation (but also to cerebral blood flow and volume). This modality is essentially used for detecting brain activation (functional MR). | |
| ... | ... | ... | ... |
| 110827 | Tissue Velocity | Velocity of tissue based on Doppler measurements. | |
| 110828 | Flow Velocity | Velocity of blood flow based on Doppler measurements. | |
| 110829 | Flow Variance | Statistical variance of blood velocity relative to mean. | |
| 110830 | Elasticity | Scalar value related to the elastic properties of the tissue. | |
| 110831 | Perfusion | Scalar value related to the volume of blood perfusing into tissue. | |
| 110850 | X-Ray Attenuation | Decrease in the number of photons in an X-Ray beam due to interactions with the atoms of a material substance. Attenuation is due primarily to two processes, absorption and scattering. | |
| 110851 | X-Ray Attenuation Coefficient | Coefficient that describes the fraction of a beam of X-Rays or gamma rays that is absorbed or scattered per unit thickness of the absorber. This value basically accounts for the number of atoms in a cubic cm volume of material and the probability of a photon being scattered or absorbed from the nucleus or an electron of one of these atoms. | |
| 110852 | MR signal intensity | Signal intensity of an MR image, not otherwise specified. | |