Status	Final Text
Date of Last Update	2019/03/26
Person Assigned	David Clunie mailto:dclunie@dclunie.com
Submitter Name	QIICR
Submission Date	2018/08/12

Correction Number CP-1848
Log Summary: Add concepts for relative blood flow and volume with reference regions
Name of Standard PS3.3, PS3.6, PS3.16, PS3.17 2019a + CP 1835
Rationale for Correction: Various MR, CT and PET techniques provide estimates of blood flow and volume that may be reproducibly expressed as relative rather than absolute values. Extend the current concepts, which are absolute, to include relative variants, and include "absolute" in the code meaning of the current concepts. Also, add concepts to describe covariates such as what location was used for the relative reference (ipsi- or contra-lateral, white or gray matter, anatomic location, size). Extend the Quantity Definition Sequence to allow for one level of modifiers to avoid a combinatorial expansion of pre-coordinated codes (e.g., to describe the laterality or size of a reference region). Update the Physical Quantity Descriptors context group to include the concepts already used in the ADC example in PS3.17 EEEE as well as those introduced herein. Retire pre-coordinated concepts specific to the brain, since a single concept is applicable to the brain and other regions, and the region can be post-coordinated or is implicit from context. *[Ed.Note: ipsi and contralateral in SNOMED-DICOM subset Request ID 737901.]*
Correction Wording:

Amend DICOM PS3.17 by adding the following new content:

OOOO Encoding Perfusion Parameters for Parametric Maps and ROI Measurements (Informative)

This Annex contains examples of how to encode perfusion models and acquisition parameters within the Quantity Definition Sequence of Parametric Maps and in ROIs in Measurement Report SR Documents.

Some measurements described as "relative" or "normalized" are calculated by dividing the measurement in a region of interest by a corresponding measurement from a reference region chosen for comparison purposes.

The approach suggested is to describe that a perfusion value is being measured by using absolute or relative regional blood flow or volume (generic) as the concept name of the numeric measurement, and to add post-coordinated concept modifiers to describe:

- the general anatomic location and type of finding that mirror common usage of terminology specific to the application
- the size of any reference region used
- a coded description of the location of any reference region in terms of:
  - anatomic site (drawn from CID 7192 "Anatomical Structure Segmentation Property Types")
  - laterality (drawn from CID 244 “Laterality” or CID 246 “Relative Laterality”)

Also illustrated is how the (121050, DCM, "Equivalent Meaning of Concept Name") can be used to communicate a single human readable textual description for the entire concept.

The example used is from the oncology domain, but similar patterns can be used for other applications, e.g., for stroke.

OOOO.1 Encoding Relative Cerebral Tumor Blood Flow for Parametric Maps

This example shows how to use the Table C.7.6.16-12b “Real World Value Mapping Item Macro Attributes” to describe pixel values of blood flow maps. It elaborates on the simple example provided in Section C.7.6.16.2.11.1.2 “Real World Values Mapping Sequence Attributes” by adding coded concepts that describe the location of the measurement and the location and size of the reference region.

- Real World Value Mapping Sequence (0040,9096)
  - ...
  - Real World Value Intercept (0040,9224) = "0"
  - Real World Value Slope (0040,9225) = "1E-03"
  - LUT Explanation (0028,3003) = "Relative Cerebral Tumor Blood Flow, relative to 150mm2 contralateral normal cerebellar gray matter"
  - LUT Label (0040,9210) = "rCBF"
  - Measurement Units Code Sequence (0040,08EA) = ({ratio}, UCUM, "ratio")
  - Quantity Definition Sequence (0040,9220):
    - CODE (G-C1C6, SRT, "Quantity") = (126397, DCM, "Relative Regional Blood Flow)
    - CODE (G-C0E3, SRT, "Finding Site") = (T-A0100, SRT, "Brain")
    - CODE (121071, DCM, "Finding") = (M-8FFFF, SRT, "Neoplasm")
    - CODE (C94970, NCIt, "Reference Region") = (T-A6040, SRT, "Cerebellar Cortex")
      - CODE (G-C171, SRT, "Laterality") = (R-40357, SRT, "Contralateral")

- NUMERIC (G-A166, SRT, "Area") = 150 (mm2, UCUM, "mm2")
- TEXT (121050, DCM, "Equivalent Meaning of Concept Name") = "Relative cerebral tumor blood flow relative to 150mm2 contralateral normal cerebellar gray matter"

In this usage, the text of the (121050, DCM, "Equivalent Meaning of Concept Name") is redundant with the value of LUT Explanation (0028,3003); either or both could be omitted.

The qualifiers of the quantity in this example, specifically the finding and finding site, are intentionally more generic (i.e., brain and neoplasm, respectively) than the more specific locations used in the SR examples that follow (i.e., left temporal lobe and primary neoplasm), since the purpose is to specify the type of the quantity, not encode an entire report in the quantity definition.

The nesting of the indented modifiers in the example illustrates that laterality and area are modifiers of the reference region (i.e., encoded in the Content Item Modifier Sequence (0040,0441) of the Quantity Definition Sequence (0040,9220)).

OOOO.2 Encoding Relative Cerebral Tumor Blood Volume for ROIs in Measurement Report SR Documents

This example shows how to describe the total relative cerebral blood volume value of a region of interest that is a tumor in the left temporal lobe. In this case the template used is TID 1419 ROI Measurements within TID 1411 “Volumetric ROI Measurements” to separately encode the ROI with the total relative CBV and the ROI for the reference region with its size, with the relationship between them implicit in the presence of a coded reference region.

For clarity, the enclosure of the content items within a Measurement Group container and the accompanying tracking identifiers and spatial information (coordinates and image and/or segmentation references) are not shown here.

- CODE (121071, DCM, "Finding") = (M-80003,SRT,"Neoplasm, Primary")
- NUM (126398, DCM, "Relative Regional Blood Volume) = 1.2 ({ratio}, UCUM, "ratio")
  - *HAS CONCEPT MOD* CODE (G-C0E3, SRT, "Finding Site") = (T-A2500, SRT, "Temporal lobe")
    - *HAS CONCEPT MOD* CODE (G-C171, SRT, "Laterality") = (G-A101, SRT, "Left")
  - *HAS CONCEPT MOD* CODE (121401, DCM, "Derivation") = (R-40507, SRT, "Total")
  - *HAS CONCEPT MOD* TEXT (121050, DCM, "Equivalent Meaning of Concept Name") = "Total tumor blood volume relative to 150mm2 contralateral normal cerebral white matter"

The reference region, its blood flow and size, would be specified as:

- CODE (121071, DCM, "Finding") = (C94970, NCIt, "Reference Region")
- NUM (126391, DCM, "Absolute Regional Blood Volume) = 34.6 (ml/(100.ml), UCUM, "ml/(100.ml)")
  - *HAS CONCEPT MOD* CODE (G-C0E3, SRT, "Finding Site") = (T-A2030, SRT, "Cerebral White Matter")
    - *HAS CONCEPT MOD* CODE (G-C171, SRT, "Laterality") = (R-40357, SRT, "Contralateral")
  - *HAS CONCEPT MOD* CODE (121401, DCM, "Derivation") = (R-40507, SRT, "Total")
- NUM (G-A166, SRT, "Area") = 150 (mm2, UCUM, "mm2")

Alternatively, if the absolute blood volume of the reference region is not available, then its size can be specified alone, e.g.:

- CODE (121071, DCM, "Finding") = (C94970, NCIt, "Reference Region")
- NUM (G-A166, SRT, "Area") = 150 (mm2, UCUM, "mm2")
  - *HAS CONCEPT MOD* CODE (G-C0E3, SRT, "Finding Site") = (T-A2030, SRT, "Cerebral White Matter")
    - *HAS CONCEPT MOD* CODE (G-C171, SRT, "Laterality") = (R-40357, SRT, "Contralateral")

The use of a specific reference region may be made explicit if the detailed information for both of the two source measurements, the absolute CBV for the lesion and the reference region, is available, in which case they could be encoded as their own instances of TID 1411 “Volumetric ROI Measurements”, and then the derived relative measurement encoded using TID 1420 "Measurements Derived From Multiple ROI Measurements", as follows:

- NUM (126398, DCM, "Relative Regional Blood Volume) = 1.2 ({ratio}, UCUM, "ratio")
  - *R-INFERRED FROM* reference to measurement group content item of absolute measurement (Row 1 of TID 1411)
  - *R-INFERRED FROM* reference to measurement group content item of reference region measurement (Row 1 of TID 1411)

OOOO.5 Informative References

This section lists useful references related to the taxonomy of perfusion measurements.

OOOO.5.1 Perfusion Measurement Descriptions

[Wetzel 2002] *Radiology*. Wetzel SG, Cha S, Johnson G, and et al. 2002. 224. 3. 797–803. “Relative Cerebral Blood Volume Measurements in Intracranial Mass Lesions: Interobserver and Intraobserver Reproducibility Study”. http://dx.doi.org/10.1148/radiol.2243011014 .

[Bjørnerud 2010] *J Cereb Blood Flow Metab*. Bjørnerud A and Emblem KE. 2010. 30. 5. 1066–78. “A fully automated method for quantitative cerebral hemodynamic analysis using DSC–MRI”. http://dx.doi.org/10.1038/jcbfm.2010.4 .

[Knutsson 2004] *Magnetic Resonance Imaging*. Knutsson L, Ståhlberg F, and Wirestam R. 2004. 22. 6. 789–98. “Aspects on the accuracy of cerebral perfusion parameters obtained by dynamic susceptibility contrast MRI: a simulation study”. http://dx.doi.org/10.1016/j.mri.2003.12.002 .

[Ziegelitz 2009] *Magnetic Resonance in Medicine*. Ziegelitz D, Starck G, Mikkelsen IK, and et al. 2009. 62. 1. 56–65. “Absolute quantification of cerebral blood flow in neurologically normal volunteers: Dynamic-susceptibility contrast MRI-perfusion compared with computed tomography (CT)-perfusion”. http://dx.doi.org/10.1002/mrm.21975 .

[Jain 2011] *AJNR*. Jain R. 2011. 32. 9. 1570-1577. “Perfusion CT Imaging of Brain Tumors: An Overview”. http://doi.org/10.3174/ajnr.A2263 .

[Wintermark 2001] *AJNR*. Wintermark M, Thiran JP, Maeder P, and et al. 2001. 22. 5. 905–14. “Simultaneous measurement of regional cerebral blood flow by perfusion CT and stable xenon CT: a validation study”. http://www.ajnr.org/content/22/5/905 .

*Amend DICOM PS3.16 as follows (changes to existing text are bold and **underlined** for additions and ~~**struckthrough**~~ for removals):*

CID 4108 Perfusion Model Parameters

Resources: **HTML | FHIR JSON | FHIR XML | IHE SVS XML**
Type: **Extensible**
Version: ~~**20161106**~~**20190326**
UID: **1.2.840.10008.6.1.993**

Table CID 4108. Perfusion Model Parameters

Coding Scheme Designator	Code Value	Code Meaning	SNOMED-CT Concept ID	UMLS Concept Unique ID	Units
~~**DCM**~~	~~**113055**~~	~~**Regional Cerebral Blood Flow**~~			~~**DT (ml/(100.ml)/min, UCUM, "ml/(100.ml)/min")**~~ ~~**DT (ml/(100.g)/min, UCUM, "ml/(100.g)/min")**~~

Coding Scheme Designator	Code Value	Code Meaning	SNOMED-CT Concept ID	UMLS Concept Unique ID	Units
DCM	126390	**Absolute** Regional Blood Flow			DT (ml/(100.ml)/min, UCUM, "ml/(100.ml)/min") DT (ml/(100.g)/min, UCUM, "ml/(100.g)/min")
~~**DCM**~~	~~**113056**~~	~~**Regional Cerebral Blood Volume**~~			~~**DT (ml/(100.ml), UCUM, "ml/(100.ml)")**~~ ~~**DT (ml/(100.g), UCUM, "ml/(100.g)")**~~
DCM	126391	**Absolute** Regional Blood Volume			DT (ml/(100.ml), UCUM, "ml/(100.ml)") DT (ml/(100.g), UCUM, "ml/(100.g)")
DCM	**126397**	**Relative Regional Blood Flow**			**DT ({ratio}, UCUM, "ratio")**
DCM	**126398**	**Relative Regional Blood Volume**			**DT ({ratio}, UCUM, "ratio")**
DCM	113052	Mean Transit Time			DT (s, UCUM, "s")
DCM	113069	Time To Peak			DT (s, UCUM, "s")
DCM	126392	Oxygen Extraction Fraction			
DCM	113084	Tmax			DT (s, UCUM, "s")

Note

Previously, concepts specific to the brain (e.g., regional cerebral blood flow) were included in this Context Group, but these have been retired in favor of using the non-body-part-specific concepts. See DICOM PS3.16 2019a.

CID 9000 Physical Quantity Descriptors

Resources: **HTML | FHIR JSON | FHIR XML | IHE SVS XML**
Type: **Extensible**
Version: **~~20141110~~20190326**
UID: **1.2.840.10008.6.1.1010**

Table CID 9000. Physical Quantity Descriptors

Coding Scheme Designator	Code Value	Code Meaning	SNOMED-CT Concept ID	UMLS Concept Unique ID
SRT	G-C1C6	Quantity	246205007	C1265611
DCM	121401	Derivation		
SRT	G-C036	Measurement Method	370129005	C1299991
SRT	**G-C0E3**	**Finding Site**	**363698007**	**C1285538**
DCM	**121071**	**Finding**		
NCIt	**C94970**	**Reference Region**		**C2986814**
DCM	**113241**	**Model fitting method**		
DCM	**113240**	**Source image diffusion b-value**		
DCM	**121050**	**Equivalent Meaning of Concept Name**		

Note

1. The concept (G-C1C6, SRT, "Quantity"), lacking a formal definition in SNOMED, is assumed in this usage to be synonymous with the concept defined for "quantity" in Joint Committee for Guides in Metrology (JCGM), *International Vocabulary of Metrology, Basic and General Concepts and Associated Terms* (http://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2012.pdf); the definition is "property of a phenomenon, body, or substance, where the property has a magnitude that can be expressed as a number and a reference". That document further distinguishes a "physical quantity", "chemical quantity", and "biological quantity", though no such distinction is implied here, and "quantity" is assumed to be all inclusive.

2. In a parametric map, the finding site will sometimes be implicit, e.g., if specified in the Anatomic Region Sequence (0008,2218) elsewhere in the instance. It may need to be explicitly specified if the instance covers a broader anatomic region than that from which the quantity was derived. The finding site is anatomical, and distinct from morphological change, which might be described in finding, e.g., lesion or tumor.

CID 244 Laterality

Resources: **HTML | FHIR JSON | FHIR XML | IHE SVS XML**
Type: **Non-Extensible**
Version: **20030108**
UID: **1.2.840.10008.6.1.37**

Table CID 244. Laterality

Coding Scheme Designator	Code Value	Code Meaning	SNOMED-CT Concept ID	UMLS Concept Unique ID
SRT	G-A100	Right	24028007	C0205090
SRT	G-A101	Left	7771000	C0205091
SRT	G-A102	Right and left	51440002	C0238767
SRT	G-A103	Unilateral	66459002	C0205092

Amend DICOM PS3.16 adding the following new content:

CID 246 Relative Laterality

Resources: **HTML | FHIR JSON | FHIR XML | IHE SVS XML**
Type: **Non-Extensible**
Version: **20190326**
UID: **1.2.840.10008.6.1.1279**

Table CID 246. Relative Laterality

Coding Scheme Designator	Code Value	Code Meaning	SNOMED-CT Concept ID	UMLS Concept Unique ID
SRT	R-40356	Ipsilateral	255208005	C0441989
SRT	R-40357	Contralateral	255209002	C0441988

D DICOM Controlled Terminology Definitions (Normative)

Table D-1. DICOM Controlled Terminology Definitions (Coding Scheme Designator "DCM" Coding Scheme Version "01")

Code Value	Code Meaning	Definition	Notes
113055	*Regional Cerebral Blood Flow*	*The absolute flow rate of blood perfusing a region of the brain as volume per mass per unit of time. The mass divisor may be approximated by a measurement of volume assuming a tissue density of 1.*	***Retired.***
113056	*Regional Cerebral Blood Volume*	*The absolute volume of blood perfusing a region of brain as volume per mass. The mass divisor may be approximated by a measurement of volume assuming a tissue density of 1.*	***Retired.***
126390	**Absolute** Regional Blood Flow	The absolute flow rate of blood perfusing a region as volume per mass per unit of time. The mass divisor may be approximated by a measurement of volume assuming a tissue density of 1.	
126391	**Absolute** Regional Blood Volume	The absolute volume of blood perfusing a region as volume per mass. The mass divisor may be approximated by a measurement of volume assuming a tissue density of 1.	
126397	**Relative Regional Blood Flow**	**The relative flow rate of blood perfusing a region. Obtained by dividing the absolute flow rate of blood perfusing a region by the absolute flow rate of blood perfusing a reference region.**	
126398	**Relative Regional Blood Volume**	**The relative volume of blood perfusing a region. Obtained by dividing the absolute volume of blood perfusing a region by the absolute volume of blood perfusing a reference region.**	

*Amend DICOM PS3.3 as follows (changes to existing text are bold and **underlined** for additions and **~~struckthrough~~** for removals):*

10.2 Content Item Macro

Table 10-2. Content Item Macro Attributes Description

Attribute Name	Tag	Type	Attribute Description
Value Type	(0040,A040)	1	The type of the value encoded in this name-value Item...
...	...	...	...

10.2.1 Content Item With Modifiers Macro

Content Item with Modifiers is a means of describing structured content which needs a Content Item with single optional level of modifiers, i.e. a two-level structure of Content Items. An invocation of the Content Item with Modifiers Macro will usually specify the allowed values using a Protocol Context Template in ????, which allows a single Nesting Level (see in ????). Constraints on the use of this Macro may be specified in ????, which may be invoked in IODs in ????.

Table 10.2.1-1. Content Item with Modifiers Macro Attributes

Attribute Name	Tag	Type	Attribute Description
Include Table 10-2 “Content Item Macro Attributes Description”			*No Baseline TID is defined.*
Content Item Modifier Sequence	(0040,0441)	3	Specifies modifiers for the Content Item. One or more Items are permitted in this Sequence.
>Include Table 10-2 “Content Item Macro Attributes Description”			*No Baseline TID is defined.*

C.7.6.16.2.11 Real World Value Mapping Macro

...

Table C.7.6.16-12b. Real World Value Mapping Item Macro Attributes

Attribute Name	Tag	Type	Attribute Description
...			
Quantity Definition Sequence	(0040,9220)	3	A list of name-value pairs that describe the characteristics of the quantity represented by the Real World Value. One or more Items are permitted in this Sequence. One of the Items shall have a concept name that specifies the quantified characteristic, though it is not required that (G-C1C6, SRT, "Quantity") be used if there is a reason to use a similar concept from a different coding scheme. Other Items may be concept modifiers, such as (G-C036, SRT, "Measurement Method"). The order of the Items is not significant.
~~>Include Table 10-2 "Content Item Macro Attributes Description"~~ ***>Include Table 10.2.1-1 "Content Item with Modifiers Macro Attributes"***			Baseline TID is TID ttt1 "Real-World Quantity Definition".

C.7.6.16.2.11.1 Real World Value Representation

C.7.6.16.2.11.1.2 Real World Values Mapping Sequence Attributes

...

The quantity that the real world values represent may be described by the Quantity Definition Sequence (0040,9220), which consists of a list of name-value pairs, in which the coded concept name specifies what aspect of the physical quantity is being described.

Note

1. For example, **Relative Regional** ~~**Cerebral**~~ Blood Flow ~~**(CBF)**~~ may be described by units and quantity as follows:

   - Measurement Units Code Sequence (0040,08EA) = (~~**ml/[100]g/min**~~**{ratio}**, UCUM, "~~**milliliter per 100 gram per minute**~~**ratio**")
   - Quantity Definition Sequence (0040,9220):
     - (G-C1C6, SRT, "Quantity") = (~~**113055**~~**126397**, DCM, "**Relative** Regional ~~**Cerebral**~~ Blood Flow")

   Additional information about how the relative blood flow was derived, e.g., the reference region used, can also be encoded as name-value pairs in the Quantity Definition Sequence (0040,9220). See the example in Annex OOOO "Encoding Perfusion Parameters for Parametric Maps and ROI Measurements (Informative)" in PS3.17.

2. For example, the Apparent Diffusion Coefficient (ADC) may be described by units and quantity as follows:

   - Measurement Units Code Sequence (0040,08EA) = (mm2/s, UCUM, "mm2/s")
   - Quantity Definition Sequence (0040,9220):
     - (G-C1C6, SRT, "Quantity") = (113041, DCM, "Apparent Diffusion Coefficient")

   Additional information about how the ADC was derived, e.g., the model used, method of fitting and acquisition b-values used, can also be encoded as name-value pairs in the Quantity Definition Sequence (0040,9220). Other diffusion models and quantities are also defined. See the example in Annex EEEE "Encoding Diffusion Model Parameters for Parametric Maps and ROI Measurements (Informative)" in PS3.17.