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DEVELOPMENT OF A MODIFIED LIST FOR STANDARDIZED STUDY DESCRIPTIONS IN THE IMPLEMENTATION OF DOSE MANAGEMENT SYSTEMS IN RADIOLOGY

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ABSTRACT

Diagnostic Radiology is an important field in medicine used as a diagnostic tool for diseases and injuries evaluation. However, exposure to high radiation doses could have negative impact on someone's health, therefore a dose management solution is needed to organize and coordinate the patient dose values. It is crucial to present the role of standardization study descriptions in the implementation of dose management systems in radiology. RadLex Playbook is one of the standardization study descriptions. With over 1000 CT scans the implementation of the mapping structure is very complicated. Therefore, a modified version is needed to reduce the number of examinations due to its possible problems through data mapping by suggesting a new list called "a reduced and embedded RadLex Playbook". To achieve this, three major systems were investigated. RIS (which was obtained from a German institute), DRL (using the German standardized study description) and RadLex Playbook. These systems were suggested to develop a strategy for data mapping and radiology procedure coded in different institutions. Direct mapping between RIS and DRL works only on specific institutionalized cases, therefore RadLex will act as an intermedium in between. Because RadLex has too many study descriptions, the suggested reduced list may help.

KEYWORDS: Radiology study descriptions, RadLex Playbook, Radiology Information System, Diagnostic Reference Level, Standardization, Dose management
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1. INTRODUCTION

Diagnostic Radiology is a specific field in the medicine which is an important diagnostic tool for diseases and injuries evaluation. It has an integral part monitoring treatments and diagnostic outcome (Radiology E. S., 2009). Since early 1895 radiology and radiological technologies have been developed significantly to enhance the practice of diagnosis and routine clinical medicine. Radiologists are continuously improved and adopted new technologies which ensure patient's benefits as well as the whole healthcare system (Jeganathan *et. al.*, 2014). It has also offered a scope of imaging procedures such as the computed tomography in order to gain images of the insides of the body organs (Radiology I. I., 2016).

Computed tomography (CT) as one of the useful techniques in diagnostic radiology has a very extensive scope of clinical functions; therefore, it is an important diagnostic method (Bosch de Basea *et. al.*, 2015). The CT scanning is applicable for children and adults due to its profoundly shortened imaging time in comparison to various other techniques, e.g. Magnetic Resonance Imaging. During the last two decades the CT scanner availability has been expanded through the European countries and worldwide. Since then the awareness for its benefits as well as the side effects has been expanding constantly (Bosch de Basea *et. al.*, 2015). However, the increase in the number of CT scan examinations has led to the subjection of patients to increased radiation doses (Balkay *et. al.*, 2013). To ensure adequate doses that a patient may receive in the different x-ray examinations, a quality management system should be employed (Bastião Silva *et. al.*, 2014). Therefore, as a part of the quality management

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in many countries Diagnostic Reference Levels (DRL) has been established.

The DRL can be regarded as benchmarks for the optimization of patient protection and imaging which were introduced by the International Commission on Radiological Protection (ICRP) in the 1990s (COMMISSION, 2018). This was established in order to ensure that doses to which patients are subjected are as low as reasonably possible not only in CT, but also in other radiological examinations in which the specified dose levels are not exceeding the accepted averages (Bastião Silva *et. al.*, 2014). To increase the levels of safety, a management solution is needed to organize and coordinate the individual patient dose values which were mostly collected manually until recently. By applying dose management, tracking the radiation doses for reviewing and optimizing purposes may be possible (Parakh *et. al.*, 2016). However, each radiology department in different institutes has their own list of procedure descriptions and internal codes. These internal codes are also related to a corresponding image procedure where an associated physician can select from whenever a new imaging study is needed. Since these codes and descriptions are created at an institutional level instead of a regional or even at national level, it results in a set of institution-specific procedures. Hence obstacles occur when the same or similar examination is performed in another institute which results in different codes and descriptions. This complicates interoperability, data sharing and cross institution data analytics efforts (Mabotuwana *et. al.*, 2014). A proper dose management can be used to control and prevent the increase of radiation risks; therefore, it is crucial to present the role of standardization study descriptions in the implementation of dose management systems in radiology. This is further needed for the development of standardization and optimization in order to achieve Low-Dose, which is based on the principles of "As Low As Reasonably Achievable" (ALARA) (The Diagnostic Reference Levels (DRLs) in Europe, 2007) & (Kavanagh *et. al.* , 2018). It is a big challenge to name imaging procedures since there are not standards across institutes, therefore, the Radiological Society of North-America has developed a list called RadLex Playbook (Mabotuwana *et. al.*, 2014). This list contains over 1000 CT scan variety examination study description types which made the implementation of the mapping structure very hard and complicated to be collaborated with. The aim of the present work is to suggest a modification of the RadLex Playbook by reducing the immense number of examinations due to its possible problems through data mapping. This is sought in order to make it more applicable and thus may be suggested as a new list called "a reduced and embedded RadLex Playbook". This reduced list might help to find a proper way to map institution-specific Radiology Information System data to the Diagnostic Reference Level values which are standard at national level only. This modification is applied on a German study case by using the German Diagnostic Reference Level.

2. MATERIALS AND METHODS

In this work, three major systems including the Radiology Information System, the Diagnostic Reference Level value and the RadLex Playbook were considered and used in order to suggest and develop a strategy for data mapping and radiology procedure coding in institutions.

Radiology Information System

The RIS is a database used by radiologists to create and store a patient's medical data (Nitrosi *et. al.*, 2014). The RIS data, which has been used as a study case in this work, was obtained from a German institute (clinic), which contained valuable information such as the patient ID, gender, age, protocol name or examination type, examination date and time, body region, CTDIvol, DLP etc. as shown in table 1.

Table (1):The RIS from a German institute

Gender	Patient-ID	Age	Examinatin Date	Examination Time	Number of Series	Manufacturer	Device Model	Total DLP(mGycm)	Protocol Name or Examination Type	Series Time	Body Part	Avg. CTDIvol.(mGy)	DLP(mGycm)	kVp	Tube Storm(mA)
M	1,191,597	54	2018/04/10	12:41:33	3	Philips	Ingenuity CT	1528.8	CCT /Head	12:42:28	BRAIN	54.6	764.4	120	300
M	9,059,062	69	2018/04/05	19:31:19	4	Philips	Ingenuity CT		Thorax nativ /Thorax	19:33:13	CHEST	9.4727	332.4893	120	255
M	1,969,196	57	2018/04/10	13:07:16	7	Philips	Brilliance 16		Abdomen nativ/Abdomen	13:09:23	None	10.5		120	186
M	1,255,873	75	2018/04/06	14:55:15	4	Philips	Ingenuity CT	1473.1149	Abdomen nativ /Abdomen	14:57:31	ABDOMEN	7.2976	341.5295	120	165
M	1,968,476	59	2018/04/10	12:28:34	4	Philips	Ingenuity CT	792.8685	Thorax Bolus/Abd.p.v. /Thorax	12:33:47	CHEST	5.758	264.2895	120	272
M	1,968,476	59	2018/04/10	12:28:34	4	Philips	Ingenuity CT	792.8685	Thorax Bolus/Abd.p.v. /Thorax	12:33:46	CHEST	5.758		120	272
M	1,968,476	59	2018/04/10	12:28:34	4	Philips	Ingenuity CT	1042.0797	Thorax Bolus/Abd.p.v. /Thorax	12:35:02	ABDOMEN	7.3283	347.3599	120	408
M	9,069,356	71	2018/04/10	12:15:52	4	Philips	Ingenuity CT	1208.9022	Thorax Bolus/Abd.p.v. /Thorax	12:20:46	CHEST	9.9498	402.9674	120	168
M	1,977,260	43	2018/04/10	11:49:03	3	Philips	Ingenuity CT	1662	CCT /Head	11:50:37	BRAIN	55.4	831	120	300
M	1,969,932	60	2018/04/10	11:14:13	5	Philips	Brilliance 16	3062.92	Head-Neck Angio/CTA	11:19:17	CAROTID	5.6558	169.675	120	469
M	1,969,932	60	2018/04/10	11:14:13	5	Philips	Brilliance 16	3062.92	Head-Neck Angio/CTA	11:18:23	None	2.3	2.76	120	90
M	1,962,856	87	2018/04/10	11:10:16	9	Philips	Ingenuity CT	1801.0902	4 Phasen Liver/Pancreas /Abdomen	11:15:37	ABDOMEN	5.5332	132.797	120	85
M	1,962,856	87	2018/04/10	11:10:16	9	Philips	Ingenuity CT	1801.0902	5 Phasen Liver/Pancreas /Abdomen	11:14:32	ABDOMEN	8.0233	182.9303	120	85
M	1,977,251	31	2018/04/10	13:59:42	3	Philips	Ingenuity CT		Thorax KM /Thorax	14:06:39	CHEST	17.60869		120	441
M	1,322,116	85	2018/04/10	10:51:07	2	Philips	Brilliance 16	196.6	None	10:51:36	None	0	0		30
M	1,977,238	21	2018/04/10	02:32:27	5	Philips	Brilliance 16	388.1586	Thorax CM/Thorax	02:35:13	None	3.5685		120	87
M	9,072,272	62	2018/04/09	13:51:58	3	Philips	Ingenuity CT	1508.7825	Thorax Bolus/Abd.p.v. /Thorax	13:58:16	ABDOMEN	10.8157	502.9275	120	270
M	9,025,990	59	2018/04/09	13:23:13	4	Philips	Brilliance 16	1269.9	Thorax Bolus Abd. pv/Abdomen	13:25:40	None			120	225
M	1,743,357	77	2018/04/09	12:58:59	3	Philips	Ingenuity CT	1644	CCT /Kopf	13:00:04	BRAIN	54.8		120	300
M	1,841,040	69	2018/04/09	10:01:16	4	Philips	Brilliance 16	5569.44	Pelvis - leg - Angio/CTA	10:02:03	None			120	50

To start the mapping procedure, the information taken from the data base included the protocol name which illustrate the examination study description, the body region showing which body part has been examined and the two important indexes; the volume weighted CT dose index ($CTDI_{vol}$) measured in mGy and the dose length product (DLP) measured in mGycm which are known as dosimetric indexes (Nakada Y *et. al.*, 2018). In this work, five samples were selected from table 1 including (CCT/Head, Thorax native/Thorax, 4 Phases Liver /Pancreas/Abdomen, Abdomen native/Abdomen and Head-Neck-Angio/CTA). For each sample examination type, the length (L) of the CT scan was manually calculated using the following equation (BUSHBERG *et. al.*, 2012):

$$DLP = CTDI_{vol} \times L \quad (1)$$

The data obtained using this equation was used later in the following steps of this procedure.

Diagnostic Reference Level

The DRL is a measure of optimization for radiation protection (Richard Veit, and Burkhard Bauer, 2019), which help avoiding unnecessarily high doses to the patient due to its brief imaging time, therefore, it is applicable for children and adults (Richard Veit, and Burkhard Bauer, 2019) & (Commission, 1999). In this paper, it was focused on adults alone using the German standardized study description as shown in table 2 (Stamm *et. al.*, 2017).

Table (2): Diagnostic Reference Level values for adult CT scans

Examination Type	CTDIvol (mGy)	DLP(mGycm)
Head (brain)	60	850
Facial bones	20	200
Paranasal sinusitis	8	90
Neck (facial skull till aortic arch)	15	330
CT-Angiography of carotid	20	600
Cervical spine (intervertebral disc)	25	–
Cervical spine (bones)	20	300
Chest (inclusive adrenal gland)	10	350
Lungs (high contrast, folloe up)	3	100
Chest and upper abdomen (inclusive pelvis entrance)	10	450
CT-Angiography of the entire aorta	13	800
Prospective ECG-triggered coronary angiography	20	330
Upper abdomen	15	360
Abdomen with pelvis	15	700
Torso (Chest+ abdomen + pelvis)	13	1 000
Lumbar spine (intervertebral disc)	25	–
Lumbar spine (bone)	10	180
Pelvis (soft tissue)	15	400
Pelvis (bones)	10	260
CT-Angiography pelvis - leg	8	1 000

The DRL standardized table contained the examination region or the protocol name and the two dosimetric indexes. Measuring the length in the DRL was carried out using equation (1).

This procedure also involved matching between the RIS and the DRL through mapping examinations types in the RIS data base and compared with the examinations type or region in the DRL table. The comparison was done according to the similarity between the protocol type and the body region through measuring two main and important points; the first point was between the $CTDI_{vol}$ values in both RIS and DRL, where the dose value in the RIS must be almost within the same range of the dose value as in the DRL or less and trying not to exceed it. This concern is raised due to the potential harm to a patient which can be caused regardless how small the radiation dose may be (Ozasa K *et. al.*, 2011) & (Council, 2006). The second point was comparing the length of the body region in both RIS and DRL, where the values must almost be also at same range. This mapping procedure represented as a direct mapping method between both RIS and DRL.

RadLex Playbook

The RadLex Playbook is another standardized method that was developed and released by the Radiological Society of North America (RSNA) ((RSNA), RadLex radiology lexicon, 2017). The Playbook aims to provide a standard system for naming radiology procedures based on the attributes which define an imaging exam such as MODALITY, MODALITY_MODIFIER, BODY_REGION, LATERALITY, REASON_FOR_EXAM, PHARMACEUTICAL, etc. as shown further in table 3 providing standard names and codes for radiologic studies (Mabotuwana *et. al.*, 2014) & (Wang *et. al.*, 2017). Playbook is intended to facilitate a variety of operational and quality improvement efforts ((RSNA), RadLex radiology lexicon, 2017) & (Wang *et. al.*, 2017).

Table (3): The RadLex Playbook 2.3

PROTOCOL_NAME	MODALITY	POPULATION	BODY_REGION	MODALITY_MODIFIER	PROCEDURE_MODIFIER	ANATOMIC_FOCUS	LATERALITY	REASON_FOR_EXAM	TECHNIQUE	PHARMACEUTICAL
CT ABD ANGIO WO & W IVCON	CT		ABDOMEN	ANGIOGRAPHY						WITHOUT THEN WITH IV CONTRAST
CT GUIDE ABLAT	CT			GUIDANCE				ABLATION		
CT SPINE GUIDE VPLASTY	CT		SPINE	GUIDANCE				VERTEBROPLASTY		
CT STERTXS	CT			STEREOTACTIC						
CT SPINE DENSITO	CT		SPINE	DENSITOMETRY						
CT HEAD DENTASCAN	CT		HEAD	DENTAL SCAN						
CT GUIDE NEEDLE PLCMNT	CT			GUIDANCE				NEEDLE PLACEMENT		
CT MULTI PLAN REF	CT				MULTI-PLANAR REFORMATION					
CT PELVIS PLVMTRY	CT		PELVIS	PELVIMETRY						
CT HEAD IAC WO & W IVCON	CT		HEAD			INTERNAL AUDITORY CANAL				WITHOUT THEN WITH IV CONTRAST
CT HEAD SELLA WO & W IVCON	CT		HEAD			SELLA TURCICA				WITHOUT THEN WITH IV CONTRAST
CT BONE DENSITO	CT		BONE	DENSITOMETRY						
CT ABD PELVIS COLONGRPHY SCREEN	CT		ABDOMEN	COLONOGRAPHY				SCREENING		
CT ABD PELVIS COLONGRPHY WO IVCON	CT		ABDOMEN	COLONOGRAPHY						WITHOUT IV CONTRAST
CT	CT									
CT ABD PELVIS COLONGRPHY W IVCON	CT		ABDOMEN	COLONOGRAPHY						WITH IV CONTRAST
CT HEAD IAC WO IVCON	CT		HEAD			INTERNAL AUDITORY CANAL				WITHOUT IV CONTRAST
CT HEAD IAC W IVCON	CT		HEAD			INTERNAL AUDITORY CANAL				WITH IV CONTRAST
CT BONE GUIDE RAD ABLAT	CT		BONE	GUIDANCE				RADIOFREQUENCY ABLATION		
CT ABD GUIDE RETRO BX	CT		ABDOMEN	GUIDANCE		RETROPERITONEUM		BIOPSY		
CT HEAD PERFUS W IVCON	CT		HEAD	PERFUSION						WITH IV CONTRAST
CT HEAD SINUSES WO & W IVCON	CT		HEAD			PARANASAL SINUSES				WITHOUT THEN WITH IV CONTRAST

The RadLex Playbook list version (2.3) shown in table 3, has been used in this work which contains more than 1000 CT scan examination study description (RSNA Informatics, 2017) & (Informatics, 2016). To facilitate the procedure by limiting and reducing some of these CT examination studies, a new extracted list from the original list was suggested forming the third main part of this work. In this reduced list it has been focused only at the required attributes: the PROTOCOL NAME, LATERALITY and PHARMACEUTICAL & PHASES as shown in table 4. Each of these attributes included values that were extracted from the list of Playbook excel sheet. For instance, the PROTOCOL NAME contains the EXANINATION STUDY DESCRIPTON, the LATERALITY contains of three possibilities values (LEFT, RIGHT and BILATERAL) and the PHARMACEUTICAL & PHASES, which indicates administration of contrast material, including route of administration and the possibility of performing a multiphases. These values are WITH IV CONTRAST (W), WITHOUT IV CONTRAST (WO), WITHOUT AND WITH IV CONTRAST (BOTH), ORAL CONTRAST and RECTAL CONTRAST.

Table (4): The RadLex Playbook excel template

EXAMINATION STUDY DESCRIPTION (PROTOCOL_NAME)	LATERALITY	PHARMACEUTICAL (IV CONTRAST) & PHASES

To summarize the strategy for reducing the list, it was prepared according to many different points. For instance, by eliminating and neglecting the protocols that didn't contain or involve any body regions or describe exactly which body part meant to be. Another point was by disregarding the protocols that performed types of processing or techniques by applying the same CT exam without editing that kind of processing or techniques. Excluding the protocols that mentioned low doses which had the similar exam type without the expression of low doses, where both protocols could be performed as one exam type because all CT scans had to follow the regulations of quality control in radiology dose management (Morin RL, 2014) which had to be all in the range of low doses. Excluding the protocols that edit limitation to a body region or to any kind of procedure which is similar in result for the same protocols without limitation. Examples for each of the above suggested points are shown in table 5.

Table (5): Examples of elimination of the examination types

EXAMINATION STUDY DESCRIPTION (PROTOCOL_NAME)
CT ANGIOGRAPHY WITH IV CONTRAST
CT BONE
CT ABDOMEN 3D IMAGING PROCESSING WITHOUT IV CONTRAST
CT CERVICAL SPINE GUIDANCE WITHOUT IV CONTRAST
CT CHEST ABDOMEN PELVIS LOW DOSE WITH IV CONTRAST
CT CHEST LIMITED
CT CHEST LIMITED NODULE DUAL ENERGY CT

One of the suggestion points that helped to reduce a good amount of those protocols was to merge protocols according to their classification's categories; the PHARMACEUTICAL (IV CONTRAST) & PHASES attribute with illustrating and indicating its IV CONTRAST & PHASES in the category as (W, WO, BOTH, MULTIPHASE). Similarly, it was implemented for the LATERALITY attribute by mentioning the LATERLITY category (LEFT, RIGHT, BILATERAL) as shown in table 6.

Table (6a): Examples of the examination types (protocols) before merging

EXAMINATION STUDY DESCRIPTION (PROTOCOL_NAME)	LATERALITY	PHARMACEUTICAL (IV CONTRAST) & PHASES
CT ABDOMEN PANCREAS		
CT ABDOMEN PANCREAS WITH IV CONTRAST		W
CT ABDOMEN PANCREAS WITHOUT THEN WITH IV CONTRAST		BOTH
CT ABDOMEN PANCREAS WITHOUT IV CONTRAST		WO
CT ABDOMEN MULTIPHASE PANCREAS WITHOUT THEN WITH IV CONTRAST		MULTIPHASE
CT CHEST PELVIS LOWER EXTREMITY WITH IV CONTRAST		W
CT CHEST PELVIS LOWER EXTREMITY WITHOUT THEN WITH IV CONTRAST		BOTH
CT LOWER EXTREMITY ANGIOGRAPHY		
CT LOWER EXTREMITY ANGIOGRAPHY BILATERAL	BILATERAL	
CT LOWER EXTREMITY ANGIOGRAPHY LEFT	LEFT	
CT LOWER EXTREMITY ANGIOGRAPHY LEFT WITHOUT THEN WITH IV CONTRAST	LEFT	BOTH
CT LOWER EXTREMITY ANGIOGRAPHY RIGHT	RIGHT	
CT LOWER EXTREMITY ANGIOGRAPHY RIGHT WITHOUT THEN WITH IV CONTRAST	RIGHT	BOTH
CT LOWER EXTREMITY ANGIOGRAPHY WITH IV CONTRAST		W
CT LOWER EXTREMITY ANGIOGRAPHY WITHOUT THEN WITH IV CONTRAST		BOTH

Table (6b): Examples of the examination types (protocols) after merging

EXAMINATION STUDY DESCRIPTION (PROTOCOL_NAME)	LATERALITY	PHARMACEUTICAL (IV CONTRAST) & PHASES
CT ABDOMEN PANCREAS		W.WO.BOTH,MULTIPHASE
CT CHEST PELVIS LOWER EXTREMITY		W,BOTH
CT LOWER EXTREMITY ANGIOGRAPHY	LEFT,RIGHT,BILATERAL	W,BOTH

There were other arguments for eliminating more protocols or examination study descriptions that were already covered with other similar protocols which could be considered as one protocol as shown in table 7.

Table (7): Examples of elimination of the examination types before & after

EXAMINATION STUDY DESCRIPTION (PROTOCOL_NAME)
CT ABDOMEN BIOPSY
CT ABDOMEN BIOPSY NEEDLE
CT ABDOMEN PELVIS ANGIOGRAPHY
CT ABDOMEN PELVIS ANGIOGRAPHY DUAL ENERGY CT
CT ABDOMEN LIVER
CT ABDOMEN LIVER DONOR

EXAMINATION STUDY DESCRIPTION (PROTOCOL_NAME)
CT ABDOMEN BIOPSY
CT ABDOMEN PELVIS ANGIOGRAPHY
CT ABDOMEN LIVER

After applying all those suggestions and arguments on the original RadLex Playbook list, a modified and reduced list has been developed. The protocols in the modified reduced RadLex Playbook list in this work was attempted to be mapped to the most appropriate and suitable DRL examination types according to the body regions. For example, the examination type "CT ABDOMEN" which was mapped to the examination type "Upper abdomen" in the DRL. In case of a protocol contained more than one body region for example: "CT ABDOMEN PELVIS" was mapped to the "Abdomen with pelvis "in the DRL. In other situations where protocols had an additional procedure or special processing with the body region such as the ANGIOGRAPHY procedure for example: "CT ABDOMEN ANGIOGRAPHY" was mapped to "CT-Angiography of the entire aorta" in the DRL. Those cases or examples were covered with a single DRL examination type. This study also included protocols that needed and required more than one single DRL for instance: "CT HEAD CHEST BRAIN" which was mapped to two DRL categories, the "Head (Brain)" category and "Chest (inclusive adrenal gland)" category.

The final consideration in this procedure was to apply the suggested reduced list as convenient standardized study description method in order to map between the entities of the RIS and the DRL. The mapping was done at first by applying the suggested reduced list directly to the DRL and matching them to find a standard mapping method that could be applied with different entities of RIS.

3. RESULTS AND DISCUSSION

The results and discussion using the five selected samples from the RIS excel sheet and their applications in the three systems (RIS, DRL and RadLex) obtained in this work are described in the same sequence as written in the methods & materials.

RIS and DRL mapping

The results of the calculated length of the CT scan for the five RIS samples using the mentioned equation are presented in table 8. This table also contains the calculated DRL length values of their matching examination type.

Table (8): The direct mapping between both the RIS and DRL

Examination Type	Body Part	Avg.CTDIvol.(mGy)	DLP(mGycm)	Length(cm)	DRL	CTDIvol.(mGy)	DLP(mGycm)	Length(cm)
CCT/Head	BRAIN	54.6	764.4	14	Head (Brain)	60	850	14.2
Thorax nativ /Thorax	CHEST	9.4727	332.4893	35.1	Chest (inclusive adrenal gland)	10	350	35
4 Phases Liver/Pancreas /Abdomen	ABDOMEN	5.5332	132.797	24	Upper abdomen	15	360	24
Abdomen nativ /Abdomen	ABDOMEN	7.2976	341.5295	46.8	Abdomen with pelvis	15	700	46.7
Head-Neck-Angio /CTA	CAROTID	5.6558	169.675	30	CT-Angiography of carotid	20	600	30

Through comparison of the length values of the RIS examination type samples with length value of their corresponding examination type in the DRL, the results suggest that they were acceptable and thus, a direct mapping may be developed between these two types of examinations since the dosimetric calculations in CT examinations are currently based on these two quantities (TSALAFOUTAS, and METALLIDIS, 2011). For example, the length values obtained were 14 and 14.2 cm of the CCT/Head examination type sample and in the DRL respectively. These values were found to be within the same range. This statement may be true for all other length values of the five samples in the two systems. Although the results may be considered sufficient enough for these specific five samples, however, direct mapping may not always be achievable because in many circumstances even in modern CT scanners, there are missing data since these values are not always stored within the examination archives; such as one or both of the index values in the RIS data base and therefore, if they are not manually recorded, they might get lost (TSALAFOUTAS, and METALLIDIS, 2011).

Thus, without these indexes the formula cannot be applied for direct mapping. Another issue that may prevent mapping is that each institute has its internal standards and different names for the examination type. Therefore, if this mapping procedure is applied to another RIS from a different institute it might not achieve the same acceptable results. This is because of the variety of examination study descriptions that arise from the different names used for the same procedure (Mabotuwana *et. al.*, 2014).

Reduced RadLex List

Table 9 shows a prototype of the reduced list; this modified list will be known as a reduced and amended Playbook list. This reduced list was attempted to overcome the direct mapping problems mentioned above, and for the need of using another standardized study description for the mapping procedure was a necessary requirement in order to improve the procedure.

Table (9): A Prototype of the Reduced and Amended RadLex Playbook list

EXAMINATION STUDY DESCRIPTION	LATERALITY	PHARMACEUTICAL (IV CONTRAST) & PHASES
CT ABDOMEN		W,WO,BOTH,MULTIPHASE
CT ABDOMEN ANGIOGRAPHY		W,WO,BOTH,MULTIPHASE
CT ABDOMEN ANGIOGRAPHY KIDNEY		W,BOTH
CT ABDOMEN ANGIOGRAPHY LIVER		W,BOTH,MULTIPHASE
CT ABDOMEN BIOPSY		WO
CT ABDOMEN CERVICAL SPINE		WO
CT ABDOMEN CHEST ANGIOGRAPHY		W
CT ABDOMEN CHEST LIVER		BOTH
CT ABDOMEN KIDNEY	BILATERAL	W,WO,BOTH,MULTIPHASE
CT ABDOMEN LIVER		W,WO,BOTH,MULTIPHASE
CT ABDOMEN PANCREAS		W.WO.BOTH,MULTIPHASE
CT ABDOMEN PELVIS		W,WO,BOTH,MULTIPHASE
CT ABDOMEN PELVIS CERVICAL SPINE		W,WO,BOTH
CT ABDOMEN PELVIS KIDNEY		WO,BOTH,MULTIPHASE
CT ABDOMEN PELVIS LUMBAR SPINE		WO
CT BRAIN		W,WO,BOTH
CT BRAIN CERVICAL SPINE		WO
CT BRAIN FACIAL BONES		WO
CT CERVICAL SPINE		W,WO,BOTH
CT CHEST		W,WO,BOTH,MULTIPHASE
CT CHEST ABDOMEN		W,WO,BOTH,MULTIPHASE
CT CHEST ABDOMEN ANGIOGRAPHY		W.,WO,BOTH
CT CHEST ABDOMEN PELVIS		W,WO,BOTH,MULTIPHASE
CT CHEST ABDOMEN PELVIS ANGIOGRAPHY		W,WO,BOTH
CT CHEST ANGIOGRAPHY		W,WO,BOTH,MULTIPHASE
CT CHEST CERVICAL SPINE		WO
CT FACE FACIAL BONES		W,WO,BOTH
CT HEAD BRAIN		W,WO,BOTH
CT HEAD CERVICAL SPINE		W,WO,BOTH
CT HEAD CHEST ABDOMEN PELVIS		W,WO,BOTH
CT HEAD CHEST ABDOMEN		WO
CT HEAD CHEST BRAIN		WO
CT HEAD CHEST FACIAL BONES		WO
CT HEAD FACIAL BONES		W,WO,BOTH
CT HEAD NECK		W,WO,BOTH
CT HEAD NECK ANGIOGRAPHY		W
CT HEAD PARANASAL SINUSES		W,WO,BOTH
CT LUMBAR SPINE		W,WO,BOTH
CT LOWER EXTREMITY ANGIOGRAPHY	LEFT,RIGHT,BILATERAL	W,BOTH

However, the RadLex Playbook list has its own issues and that it contains more than 1000 CT scan variety examination study description types. Because of that, it made the implementation of the mapping structure very complicated to deal and work with. Therefore, to solve this problem the modified list was suggested which was extracted from the original list to facilitate the procedure by limiting and reducing some of these CT examination studies to create a new list. After applying and implementing all the suggestions and arguments points that were explained and mentioned before in the methods and materials, a modified list was achieved with a high percent of reduction that facilitated the procedure structure for mapping in order to obtain a suggested strategy method which helped towards interoperability for mapping institution-specific RIS data to the DRL values.

The obligated conditions from the reduction list was, that it should cover all important and necessary requirements of the examination protocol types and that it also could cover all common entities of the RIS and then it could be mapped completely to the DRL standard. This reduced list was tentatively called **"reduced and amended RadLex Playbook list"** The approach of this procedure was to establish the reduction list in which several aspects were applied according to some suggestions and arguments. One of the most obvious arguments was from the modality and the application side, where it was expected that a major part of these thousand exam types, which are available in the list, were not actually used. As a matter of fact, only a limited number of very specific and basic protocols were used. At the end after the reduction procedure, only some minor modifications were going to subsist.

In this procedure after obtaining the modified list, it was mapped to the DRL and it was considered as a suggested standardized method that could cover most cases of the examination

types to achieve a sufficient and proper way for mapping and to get rid of the issue of restriction in resolution.

RadLex List and DRL mapping

Table 10 represent the result of a direct mapping between the modified reduced list and the DRL. This intermediate result may simplify for the radiologist the mapping between the modified reduced RadLex with the DRL in order to get to the final step.

Table 10 A prototype of mapping between the Reduced list and the DRL

EXAMINATION STUDY DESCRIPTION	LATERALITY	PHARMACEUTICAL (IV CONTRAST) & PHASES	DRL (EXAM STUDY REGOIN_1)	DRL (EXAM STUDY REGOIN_2)
CT ABDOMEN		W,WO,BOTH,MULTIPHASE	Upper ab-damon	
CT ABDOMEN ANGIOGRAPHY		W,WO,BOTH,MULTIPHASE	CT-Angiography af the entire aorta	
CT ABDOMEN ANGIOGRAPHY KIDNEY		W,BOTH	CT-Angiography af the entire aorta	
CT ABDOMEN ANGIOGRAPHY LIVER		W,BOTH,MULTIPHASE	CT-Angiography af the entire aorta	
CT ABDOMEN BIOPSY		WO	Upper ab-damon	
CT ABDOMEN CERVICAL SPINE		WO	Upper ab-damon	Cervicalrspine
CT ABDOMEN CHEST ANGIOGRAPHY		W	CT-Angiography af the entire aorta	
CT ABDOMEN CHEST LIVER		BOTH	Chest and upper ab-damon (inclurive pelvir entrance)	
CT ABDOMEN KIDNEY	BILATERAL	W,WO,BOTH,MULTIPHASE	Upper ab-damon	
CT ABDOMEN LIVER		W,WO,BOTH,MULTIPHASE	Upper ab-damon	
CT ABDOMEN PANCREAS		W,WO,BOTH,MULTIPHASE	Upper ab-damon	
CT ABDOMEN PELVIS		W,WO,BOTH,MULTIPHASE	Ab-damon with pelvir	
CT ABDOMEN PELVIS CERVICAL SPINE		W,WO,BOTH	Ab-damon with pelvir	Cervicalrspine
CT ABDOMEN PELVIS KIDNEY		WO,BOTH,MULTIPHASE	Ab-damon with pelvir	
CT ABDOMEN PELVIS LUMBAR SPINE		WO	Ab-damon with pelvir	Lumbarrspine
CT BRAIN		W,WO,BOTH	Head (brain)	
CT BRAIN CERVICAL SPINE		WO	Head (brain)	Cervicalrspine
CT BRAIN FACIAL BONES		WO	Head (brain)	Facial Banar
CT CERVICAL SPINE		W,WO,BOTH	Cervicalrspine (banar)	Cervicalrspine (intervertebral dirc)
CT CHEST		W,WO,BOTH,MULTIPHASE	Chest (inclurive adronal gland)	
CT CHEST ABDOMEN		W,WO,BOTH,MULTIPHASE	Chest and upper ab-damon (inclurive pelvir entrance)	
CT CHEST ABDOMEN ANGIOGRAPHY		W,,WO,BOTH	CT-Angiography af the entire aorta	
CT CHEST ABDOMEN PELVIS		W,WO,BOTH,MULTIPHASE	Tarza (Chest+ ab-damon + pelvir)	
CT CHEST ABDOMEN PELVIS ANGIOGRAPHY		W,WO,BOTH	CT-Angiography af the entire aorta	
CT CHEST ANGIOGRAPHY		W,WO,BOTH,MULTIPHASE	CT-Angiography af the entire aorta	
CT CHEST CERVICAL SPINE		WO	Chest (inclurive adronal gland)	Cervicalrspine
CT FACE FACIAL BONES		W,WO,BOTH	Facial banar	
CT HEAD BRAIN		W,WO,BOTH	Head (brain)	
CT HEAD CERVICAL SPINE		W,WO,BOTH	Head	Cervicalrspine
CT HEAD CHEST ABDOMEN PELVIS		W,WO,BOTH	Head	Tarza (Chest+ ab-damon + pelvir)
CT HEAD CHEST ABDOMEN		WO	Head	Chest and upper ab-damon (inclurive pelvir entrance)
CT HEAD CHEST BRAIN		WO	Head (brain)	Chest (inclurive adronal gland)
CT HEAD CHEST FACIAL BONES		WO	Facial banar	Chest (inclurive adronal gland)
CT HEAD FACIAL BONES		W,WO,BOTH	Facial banar	
CT HEAD NECK		W,WO,BOTH	Head	Neck (facialrskull till aartic arch)
CT HEAD NECK ANGIOGRAPHY		W	CT-Angiography af caratid	
CT HEAD PARANASAL SINUSES		W,WO,BOTH	Paranasalrsinuritir	
CT LUMBAR SPINE		W,WO,BOTH	Lumbarrspine (bone)	Lumbarrspine (intervertebral dirc)
CT LOWER EXTREMITY ANGIOGRAPHY	LEFT,RIGHT,BILATERAL	W,BOTH	CT-Angiography pelvir - leg	

Final mapping

The final step in the procedure was showing and representing the aim of this work, which was to find general method to map between the entities of the RIS and the DRL by using another convenient standardized study description method. In the previews work, some samples of the RIS data as shown already in table 8, which were taken from the German clinic and used during the direct mapping, will be used again by using the suggested reduced list to apply a general standard method as shown in table 11.

Table 11 Mapping between both the RIS and DRL using the Reduced & Amended RadLex Playbook list

Examination Type (RIS)	Body Part	EXAMINATION STUDY DESCRIPTION	LATERALITY	PHARMACEUTICAL (IV CONTRAST) & PHASES	DRL
CCT/Head	BRAIN	CT HEAD BRAIN		W,WO,BOTH	Head (Brain)
Thorax nativ /Thorax	CHEST	CT CHEST		WO	Chest (inclusive adrenal gland)
4 Phases Liver/Pancreas /Abdomen	ABDOMEN	CT ABDOMEN MULTIPHASE LIVER PANCREAS		BOTH,MULTIPHASE	Upper abdomen
Abdomen nativ /Abdomen	ABDOMEN	CT ABDOMEN		WO	Abdomen with pelvis
Head-Neck-Angio /CTA	CAROTID	CT HEAD NECK ANGIOGRAPHY		W	CT-Angiography of carotid

4. CONCLUSION AND RECOMMENDATION

Many clinical institutions were different radiology techniques are performed have their internal standards and different names for the examination types, another issue that may prevent RIS and DRL mapping.

Therefore, the role of standardization was found to be very helpful to facilitate the mapping between RIS and DRL. In this work the RadLex Playbook list was used as the standardization tool. However, the challenge was to suggest a modified list to make the RadLex Playbook more applicable for Radiologists.

In this procedure after obtaining the modified list, it was possible to map to the DRL and it was considered as a suggested standardized method that could overcome most cases of the examination types to achieve a sufficient and proper way for mapping and to avoid the issue of restriction in resolution.

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