Towards a Global Imaging Procedure Code Mapping Resource (IPCMR)

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http://www.ipcmr.org/
Disclosures

• Owner, PixelMed Publishing, LLC (Consulting)
• Editor, DICOM Standard (NEMA contractor)
• Nothing relevant to this subject
Orders/Requests Drive Imaging

- Clinician conceives of need for & places order
  - may be modulated by “appropriateness”
- Radiologist “protocols”
  - may or may not be mediated by a “code”
- Technologist/machine “performs”
  - manual or “automated protocol setting”
- PACS displays
  - procedure-specific hanging protocols
- Report dictated
  - procedure-specific templates
- Quality and performance measured
  - procedure-specific radiation dose tabulated
- Coded for billing
  - black art driven by non-clinical resource/political/commercial factors
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Retrieval Use Case Examples

• Alerts about prior studies
  – during ordering, protocolling, performing

• Retrieval of relevant priors
  – from long term archive (slow/offsite)
  – for reporting
  – for clinical users comparison

• Retrieval of relevant reports

• Different codes used inside versus outside organization
  – central or federated archives
  – old (unmigrated/unmodified) studies after merger
  – “foreign” studies imported via media or network

• Use case impact on requirements for codes/concepts
  – what was ordered/requested versus what was performed
  – how detailed the description of what was performed needs to be
State of the Art vs Incentives

- State of the art:
  - every site creates own procedure list
  - every site creates own acquisition protocols
  - every site creates own hanging protocols
  - every site creates own report templates
  - all indexed by local site’s codes (or something)

- Incentives to change internal practice (standardize):
  - re-use opportunity (does not seem to have driven change)
  - consolidation of enterprises (mergers/acquisitions)
  - consolidation of systems (unifying EMR installation)
  - one vendor, one set of universal codes?
“The nice thing about standards is that you have so many to choose from”
– Andrew Tanenbaum

Equally applicable to “standards” for coding schemes, or even just controlled terminology

Why are standard schemes not already used locally?
– poor fit to local practice
– poor coverage of local diversity
– folks just insist on inappropriately use billing codes
– historical isolation with inertia and little incentive to change (code “ghettos”)

Does new enterprise/system (esp., EMR CPOE) drive change?
– does the vendor have their own proprietary “standard”?
– counterincentive of business model for professional services customization

Perhaps we should just give up on selecting one standard
– instead map all the standards, rather than expend futile effort on evangelism
– lead many horses to different forms of compatible water (?)
– still may require inbound/outbound coercion to/from local coding scheme
Mapping: What about the UMLS?

- National Library of Medicine (NLM) Unified Medical Language System (UMLS) “metathesaurus”
  - evolving since 1986
  - more than 1 million biomedical concepts, over 100 sources

- Imaging procedures in UMLS
  - some sources of imaging procedure codes
  - some sources not yet included (e.g., RadLex)
  - driven by lexical equivalence (issue for LOINC)
  - not yet good coverage or mapping for imaging

- Improve UMLS
  - if gaps can be filled by imaging domain experts
  - requires a systematic and credible approach
UMLS – 1 procedure, 3 concepts
Imaging procedure domain is restricted
E.g. in UMLS, “BPD” may also be
  – Bronchopulmonary Dysplasia
  – Borderline Personality Disorder
In imaging (procedure) context
  – Biparietal Diameter
Unless pre-coordinated as “reason”?
Hypothetical
  – not actually encountered in IPCMR source schemes (yet) (subsumed under gestational age stuff)
Goal of Pilot Project

- Build a prototype of a “content mapping resource”
  - a list of “equivalent” concepts
  - a list of same concept in different sources
- Include as many relevant sources as available (even drafts)
  - preferably international in scope
  - SNOMED INT, GB, CA, LOINC, RadLex, JJ1017, Ontario DI, UK NICIP, ICD10PCS, ICD9CM, HCPCS, ACR Common, RANZCR BSF
- Compare lexical and semantic approaches
  - lexical – parsing strings for patterns/matches
  - semantic – “model” behind source to identify equivalent attributes
- Assess feasibility of using for production
- Identify opportunities to improve sources
  - correct errors, remove duplicates, identify ambiguities
- Consider contributing results to include in UMLS
Imaging Procedure Code Mapping Resource (IPCMR)
<table>
<thead>
<tr>
<th>IPCMR Code</th>
<th>ICMR Code</th>
<th>ICMR Definition</th>
<th>ICMR Description</th>
<th>Source Description</th>
<th>SNOMED</th>
<th>NCIIP</th>
<th>ACRCommon</th>
<th>ONTARIO/DI</th>
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SNOMED Concepts Mapped

- **SNOMED International**
  - transitive closure of “Is a” children of “Imaging (procedure)” (363679005, P0-0099A) in 2015/01/31 release

- **SNOMED UK Extension**
  - transitive closure of 2015/04/01 v19.0.0

- **SNOMED Canadian Extension**
  - transitive closure of 2012/12/21 V1.0
  - plus those in Ontario DI Code mapping
SNOMED Terms Used

• Each SNOMED Concept may have multiple (English) synonyms
  – use en-US (“Computerized”) not en-GB (“Computerised”)
  – only use current terms, not those retired/wrong
• Used the one flagged as “preferred term”
  – e.g., “Computerized axial tomography” (77477000, P5-08000)
• If not available, used “fully specified name” (FSN)
  – e.g., “Computerized axial tomography (procedure)”
• Tried, but stopped using, all other synonyms to avoid introducing ambiguity or loss of specificity
  – e.g. “CAT scan, NOS” (don’t want “not otherwise specified”)
  – e.g., “Computerized tomography without IV contrast” (wrong)
LOINC Concepts Mapped

- LOINC 2.50 2014/12
- All those with CLASS of
  - CARD.US
  - US.ECHO
  - EYE.US
  - GEN.US
  - OB.US
  - RAD
  - US.URO
LOINC Terms Used

• Short Name
  – e.g. “XXX CT” (25045-6)

• Long Common Name
  – e.g., “Unspecified body region CT”

• Did not use Related Name (constructed)
  – “CAT scan; Computed tomography; Computerized tomography; CT scan; Finding; Findings; Imaging; Misc; Miscellaneous; Other; Point in time; Radiology; Random; Unspecified”
Definitions to Consider

• What are we trying to make from what?
  – terminology
  – controlled terminology
  – interface terminology
  – lexicon
  – thesaurus
  – metathesaurus
  – ontology
  – mapping resource
Equivalence, Synonymity

• Gets philosophical
  – Socrates – “universals”

• Pragmatic – UMLS
  – “terms are identical in meaning if the vast majority of biomedical professionals would find any distinction in meaning between the two terms is inconsequential, that is, a distinction that was not supportable, a distinction without a significant difference” Powell et al Proc AMIA 2002

• Formal model based on underlying concepts
• Expedient extraction of common components
Considerations for Mapping

- If goal is only mapping
  - “canonicalized” (“normalized”) strings only need to “match”
  - i.e., their “meaning” is irrelevant (extreme: “lexical semantics”)
- If concept in source scheme has multiple terms (synonyms)
  - canonicalized version of only one of them needs to “match” those of other schemes
  - as long as not ambiguous (in producing different matches)
- If goal is to extract “meaning” (ontology)
  - canonicalized content needs to have meaning
  - canonical components defined a priori or iteratively improved
Canonical Representation

- Canonical representation itself
  - sorted unique canonical string components
    - e.g., “Anatomy:ABDOMEN Modality:CT”
  - attributes + values (e.g., UML, XML, database, etc.)
    - e.g., <Concept Anatomy=“ABDOMEN” Modality=“CT”/>

- Lexical mapping
  - extraction/conversion of string to term
  - exact match (not ranking, since fully automated)

- Semantic mapping
  - converting attribute values in source model to (different) attributes and values in IPCMR canonical representation
  - only RadLex so far (and old, pre-RadLex/LOINC version)
  - future candidates: LOINC, SNOMED, JJ1017, ACRCommon
• Not quite a “model” yet, but …
• E.g. “discography” possibilities:
  – ModalityType:Discography (unqualified modifier)
  – Object:IntervertebralDisc IDiscContrast:W
  – may be RF (assume), CT, MR (with Gd)
  – ??RG (ICD10PCS)
  – are all mentions of disc discography?
• c.f., “myelography”
  – Myelography:Yes
  – IThecalContrast:W
Lexical Mapping Approach

- Large body of literature:
  - generic
  - UMLS – biomedical
  - LOINC – lab tests & imaging procedures (report titles)
- Such techniques as
  - remove case sensitivity
  - make plurals singular
  - expand abbreviations
  - remove conjunctions
  - sort words alphabetically
  - automated stemming (not used; done manually)
  - predefined list of equivalent words
  - predefined list of equivalent multiword patterns (word order)
  - regular expressions
Ambiguities

- Source concepts may have
  - different current synonyms
  - different synonyms in different versions
  - conflict between lexical and semantically generated canonicalizations

- Canonicalization may
  - fail to disambiguate distinct concepts (i.e., “lump” rather than “split”)
  - fail to recognize implied distinctions (lack “context”)
  - be internally inconsistent or in error (especially problematic for abbreviations)
• Same Source Concept maps to different IPCMR concept
  – “Ultrasonography” (SNOMED 16310003)
  – “Diagnostic ultrasonography”: adds “Context:Diagnostic”
• Multiple different Source Concepts map to same IPCMR concept
  – duplicates from national extensions now absorbed
    • “CT and aspiration of abdomen” (420230009)
    • “Computed tomography and aspiration of abdomen” (CA - 2578450013)
  – genuine duplicates
    • “Computerized axial tomography” (77477000)
    • “CT of regions” (303678006) (assuming “regions” is spurious)
  – incorrect/dubious IPCMR lexical or semantic canonicalization
    • “CT of head” (303653007) (“structure of” rather than “entire”)
    • “CT of entire head” (408754009) (IPCMR discards “entire”)

Ambiguities
• “Lumpers” versus “splitters”

• Is a “XX Pancreas” an “XX Abdomen”?  
  – e.g., CT, MR, US

• “Spurious” Abdomen prevents merge  
  – “Modality:US Anatomy:PANCREAS” matches  
    • SNOMED, UK NICIP, Ontario-DI,LOINC, ICD10PCS  
    • Not RadLex without additional “Anatomy:ABDOMEN”

• Spurious “limited” modifier” (with respect to what?)  
  – billing artifact, useful for order/protocol, implicit in anatomy?  
  – e.g., RadLex  
    • “An ultrasound radiology orderable imaging procedure focused on the pancreas in the abdomen” (RPID2000) (removed from RadLex 2.0)  
    • “An ultrasound radiology orderable limited procedure focused on the pancreas in the abdomen” (RPID2183)  
    • in 2.0, “US Abdomen Limited Pancreas” (RPID2183)  
    • c.f. in 2.0 “US Gallbladder” (RPID1986) (state of flux +/- inconsistent policy)
• “Spurious” “coarse region” useful for some purposes
  – arguably simplifies retrieval of relevant priors
  – grouping for simplicity of appropriateness criteria for clinical decision support (ordering)

• But
  – is it needed in the human-readable term?
    • if so, complicates lexical mapping
  – is it sufficient to be implicit?
    • look up in “ontology” (by hierarchy of procedures, or of anatomy)
    • distinguish (or not) between “entire” vs. “structure of” anatomy
  – is it needed explicitly in the structured definition?
    • “behind the scenes” (assumes definition is available to recipient)
    • e.g., RadLex Body Region vs. Anatomic Focus “attributes”
    • e.g., ACRCommon “body_area” vs. “anatomy” “tags”
Is a procedure the sum of its structured components?  
  – or does it need a specific attribute value to flag it as distinct?

Challenge for both diagnostic and interventional

E.g., FAST Ultrasound
  – “Focused Assessment with Sonography in Trauma” (FAST)
  – IPCMR
    • ? “Anatomy:PLEURA Anatomy:PERICARDIUM Anatomy:PERITONEUM”
  – very specific purpose: find blood/air where it shouldn’t be
  – very specific views of narrowly selected regions:
    • pericardium: subxiphoid or parasternal views
    • pleural space, perisplenic space, Morrison’s pouch (liver and right kidney)
    • pelvis behind bladder or uterus (Pouch of Douglas)
    • +/- anterior chest: pneumomothorax (“extended”, eFAST)
Anatomy: What is a Head?

- Sometimes
  - a “head” is a “brain” (are all “brains” “heads”?)
- Sometimes it is not:
  - cranial cavity
  - face
  - facial bones
  - faciomaxillary
  - zygoma
  - zygomatic arch
- Editorial guidance for each source scheme
  - if any
  - varies significantly (often depending on primary goal)
Angiography

- XA (“catheter”) versus CT, MR
- +/- contrast
- IV DSA versus IA (versus venography)
- Angiography
  - == arteriography only?
  - == arteriography or venography?
  - includes lymphography?
- Different schemes
  - different editorial guidance (if any)
Arthrography, etc.

- Arthrography
  - do all arthrograms have intraarticular contrast if not explicitly specified?
  - if contrast but not route is specified, can one assume it is intraarticular?
  - does it matter? should one remove it if specified?
  - cf. MR angiograms where there (may be) intrinsic “contrast”

- Myelography ...

- Discography ...
Multiple Regions vs Junctions

- L-S Junction versus both L & S spine
- ICD10PCS says LS and TL “joint” when they probably mean “junction”
- UK NICIP means junction not both regions
What they say vs. meant?

• “discography w IV contrast”
• did they really mean w contrast (IDisc)?

• “fix” in IPCMR to achieve greater concordance?
• leave as is and ask source to fix?
• flag as “bad” or “improbable” in IPCMR?
• probably never used anyway if “wrong”
Statistics So Far

- **Canonicalization of any term for any source concept**
  - total number 58378
  - nothing canonicalized = 141
  - incompletely canonicalized = 12094
  - completely canonicalized = 46143 (79%)
  - completely canonicalized and has modality identified = 44419 (76%)

- **Source concepts**
  - total number 40155 (< terms due to synonyms, multiple versions of source scheme)
  - with at least one matching canonicalized synonym = 21253 (53%)
  - without at least one matching canonicalized synonym = 18902 (47%)
  - with ambiguous mapping to canonicalized synonyms = 3953 (9.8%)

- **IPCMR**
  - completely canonicalized and has modality (not necessarily “right”, or even “plausible”)
  - total number of distinct concepts = 18899 (43% of terms canonicalized with modality)
  - concept overlap estimate (source-IPCMR)/source = 21253-18899/21253*100 (11%)
Maintenance

• Need stable concepts and codes for them
  – Cimino et al “desiderata”
  – never re-use code for a different concept
• Formal definition representation may evolve
• Synthesized term may evolve
• Mappings may be
  – added/removed/split/merged
• Audit trail
  – who, what, why, when
  – events: create, release, change, retire, …
Delivery

- HTML pages with
  - IPCMR concepts mapped to source concepts
    - code, canonicalized form, synthesized description
  - source concepts with canonicalization
    - ambiguities (multiple possible mappings: synonyms)

- Machine usable content
  - CSV files with same content as HTML

- Model
  - flat list of attribute:value pairs
  - when canonicalized components mature, will formalize into a “model”
Conclusion

- See work in progress at http://www.ipcmr.org/

- Useful mapping is probably tractable
- Improve by iterative human curation of mapping rules
- Curation of veracity of result not explored yet
- There is modest overlap of schemes
- The union of all source terms is large
- Intervventional procedures are especially numerous
- Need to prioritize “useful” concepts
- Need a maintenance process after first release
- There is hope (maybe)!