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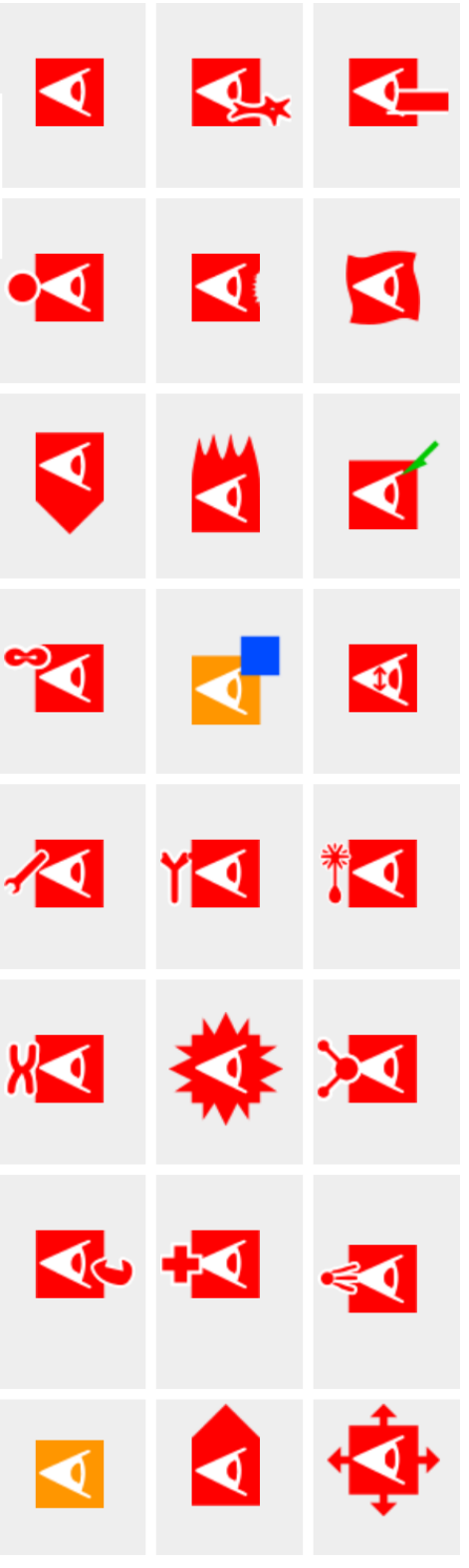
An iconic approach to the browsing of medical terminologies

Jean-Baptiste Lamy, Van Bui Thuy,
Agnès Lillo-Le Louët, Cédric Bousquet



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LIMICS
Université Paris 13, Sorbonne Paris Cité, 93017 Bobigny
Sorbonne Universités, Paris
INSERM UMRS 1142

Introduction

- **Medical terminologies: the basis of interoperability in medicine**
  - But difficult for a Humans to find the right term in 10,000+ terms!
- **In pharmacovigilance, experts often perform searches in case database**
  - *e.g.* find all cases of "renal abscess" associated with drug X
  - Adverse drug events are coded in MedDRA
  - Problems:
    - Search must be exhaustive, but natural language is very precise
    - Synonymy, polysemy, false friends: "tumor of cardia"
  - It is also difficult to obtain an overview of a terminology
- **=> we developed since 11 years VCM, an iconic language for representing medical concepts**
  - Not as precise as text, but useful for enriching texts and facilitate searches
  - Previously applied to drug knowledge, electronic health records, decision support systems
- **Objective: propose a iconic interface for browsing medical terminologies**

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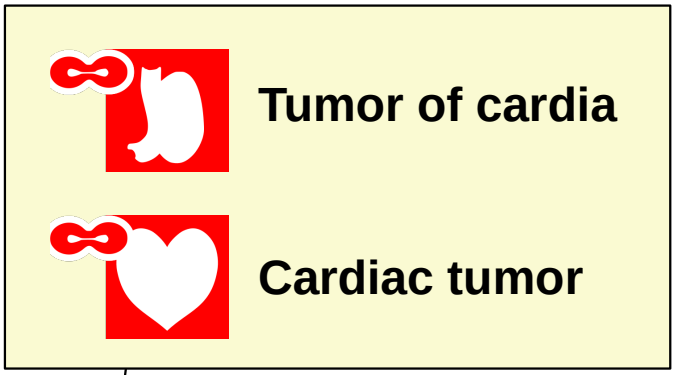

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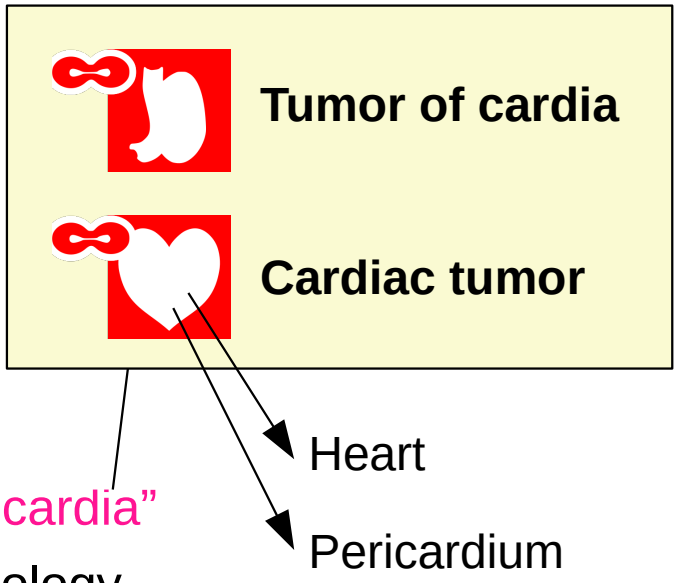

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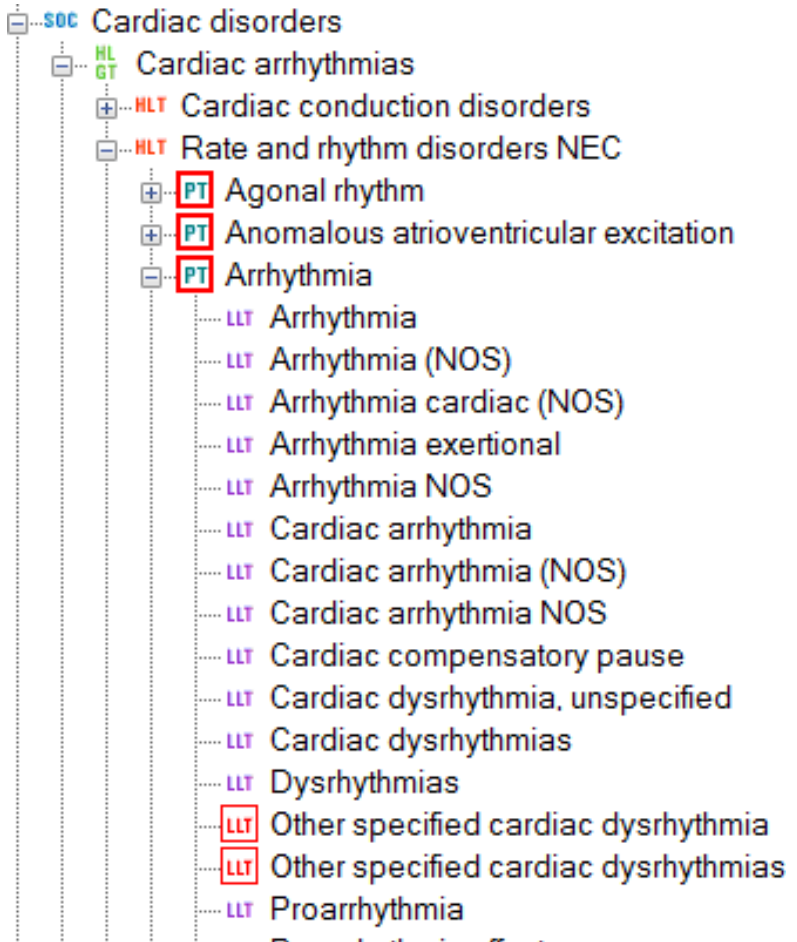
Existing approaches for browsing and searching medical terminologies

- **Navigation in a hierarchy (tree)**
  - Long and tedious, user is rapidly lost in the tree
  - Not well-suited for multiaxial terminologies (including MedDRA)
  - Overview is limited to a single level



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- **Lexical search with keywords (*e.g.* "renal abscess")**
  - Synonyms: "kidney abscess"
  - Hyponyms/hypernyms: "abscess perinephric"
  - Polysemy: "auricular" matches both heart and ear-related terms

Brown EG. Methods and pitfalls in searching drug safety databases utilising the Medical Dictionary for Regulatory Activities (MedDRA). Drug Saf 2003

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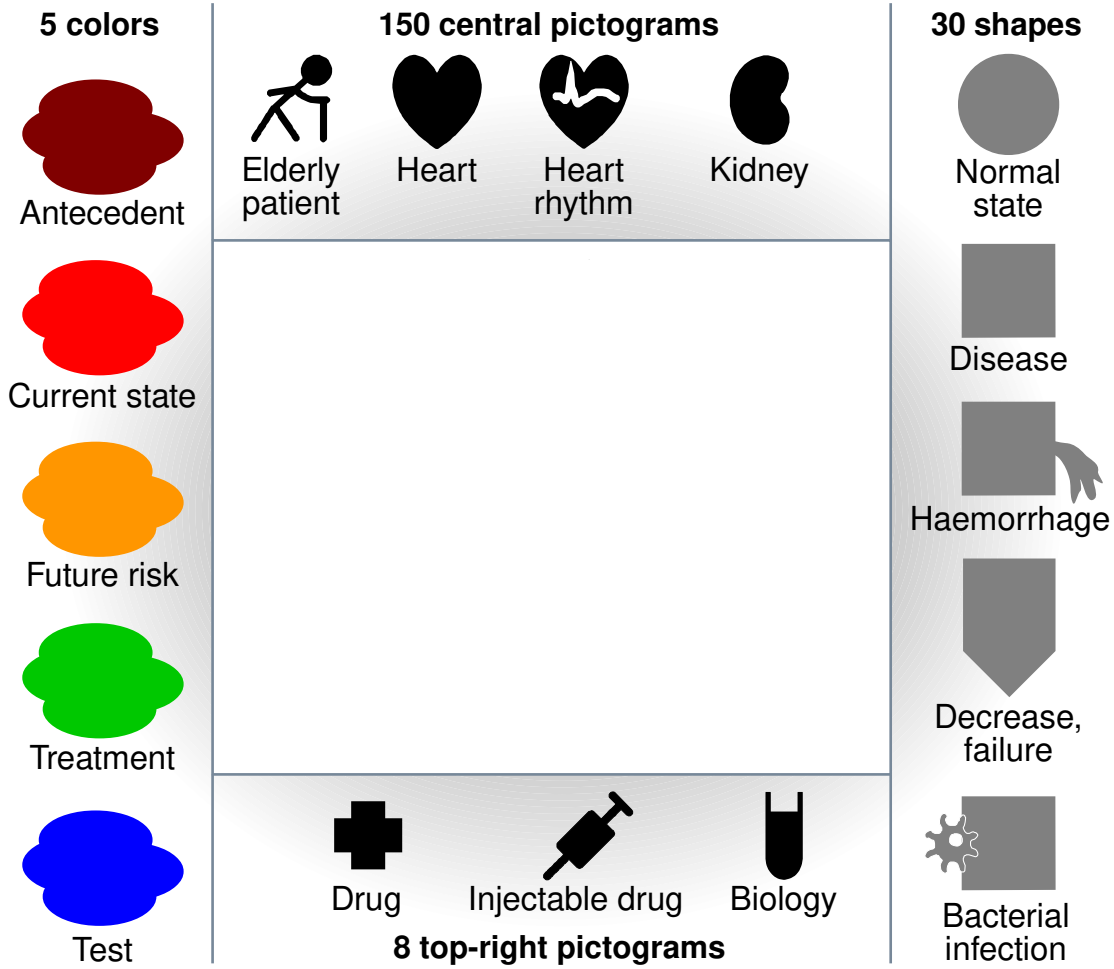
- **Post-coordination with compositional terminologies [Cornet, Lee, Souvignet]**
  - “renal abscess” => renal + abscess
  - But it requires to enter complex queries
  - **=> “Visual post-coordination” with VCM**

VCM
(Visualization of Concepts in Medicine)

- **An iconic language for medical concepts [BMC]**
  - Symptoms
  - Disorders
  - Treatments
  - Exams
  - Adverse effects
- **Combinatorial grammar**
  - 150 pictograms
  - 5 colors
  - 30 shapes
- **=> thousands of icons**



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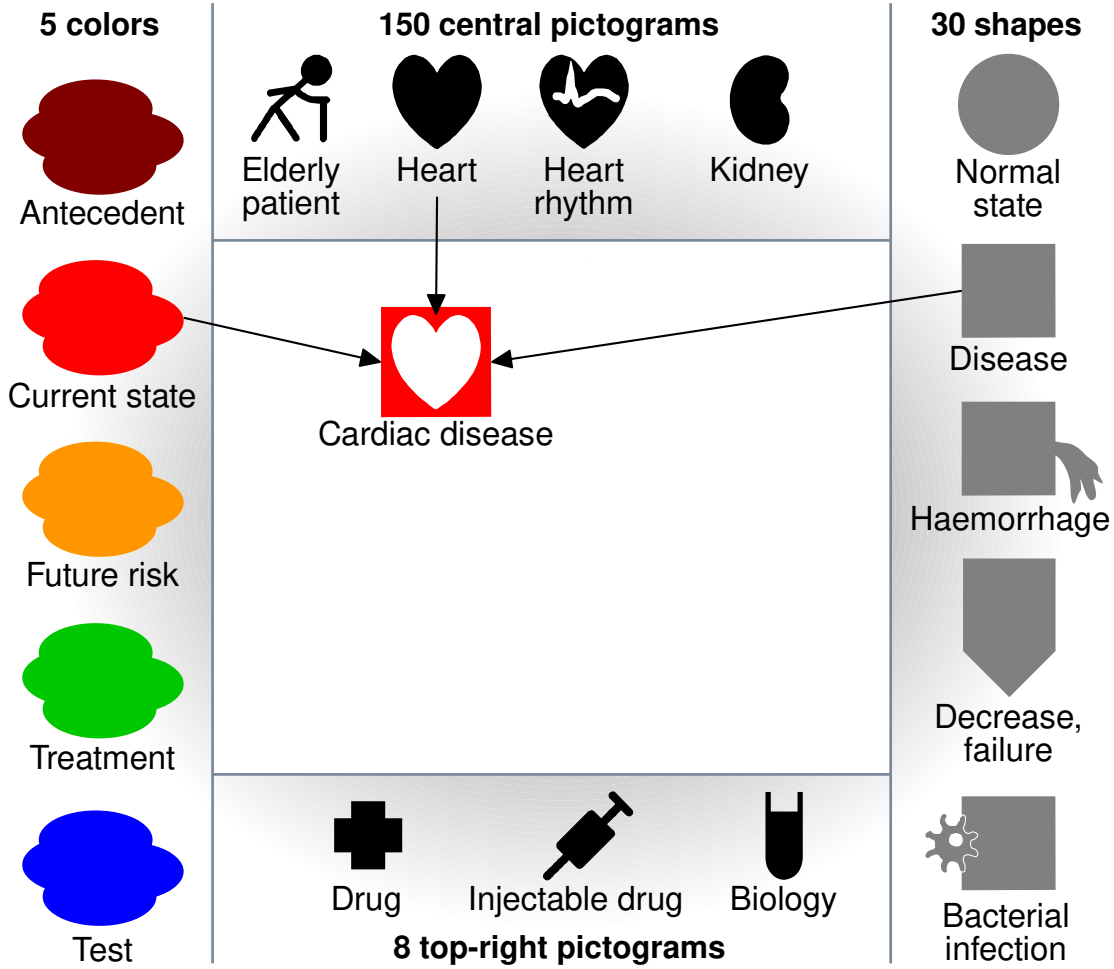

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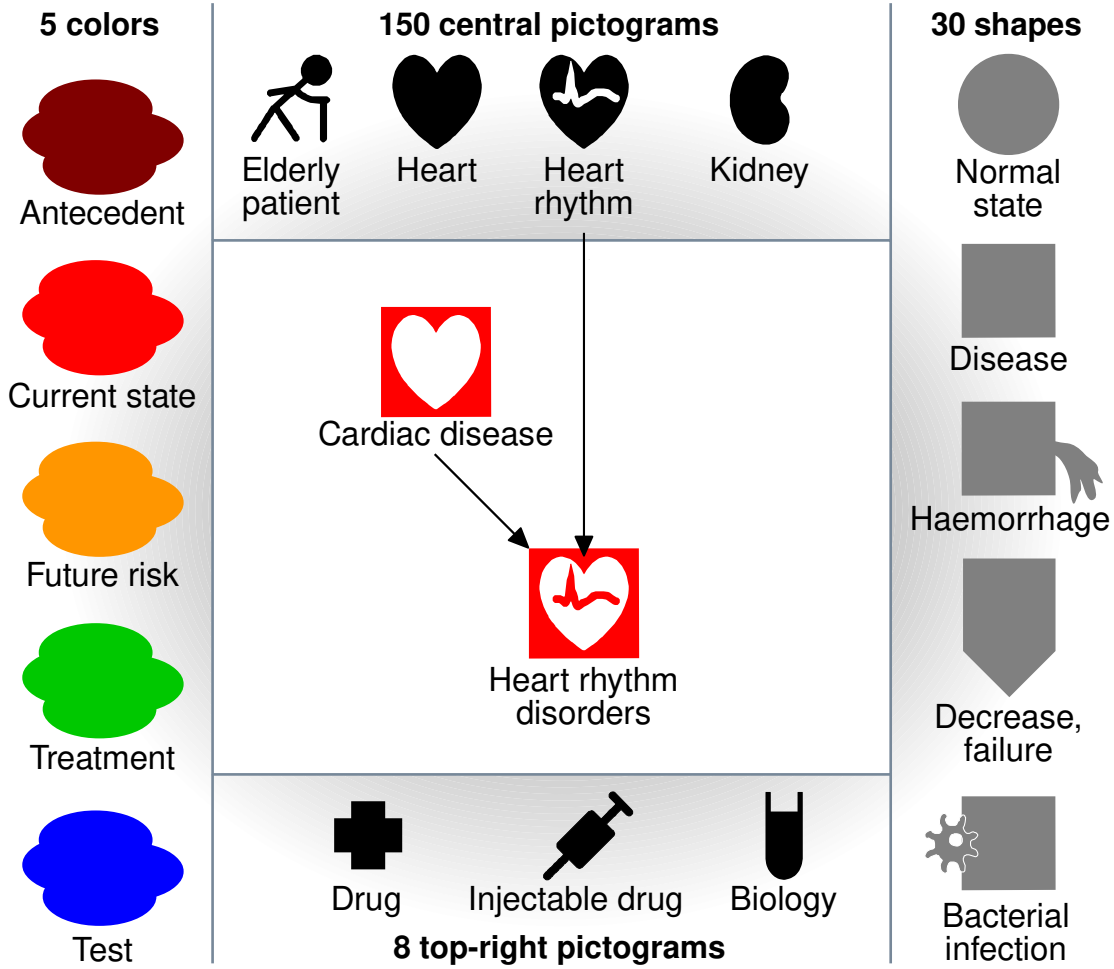

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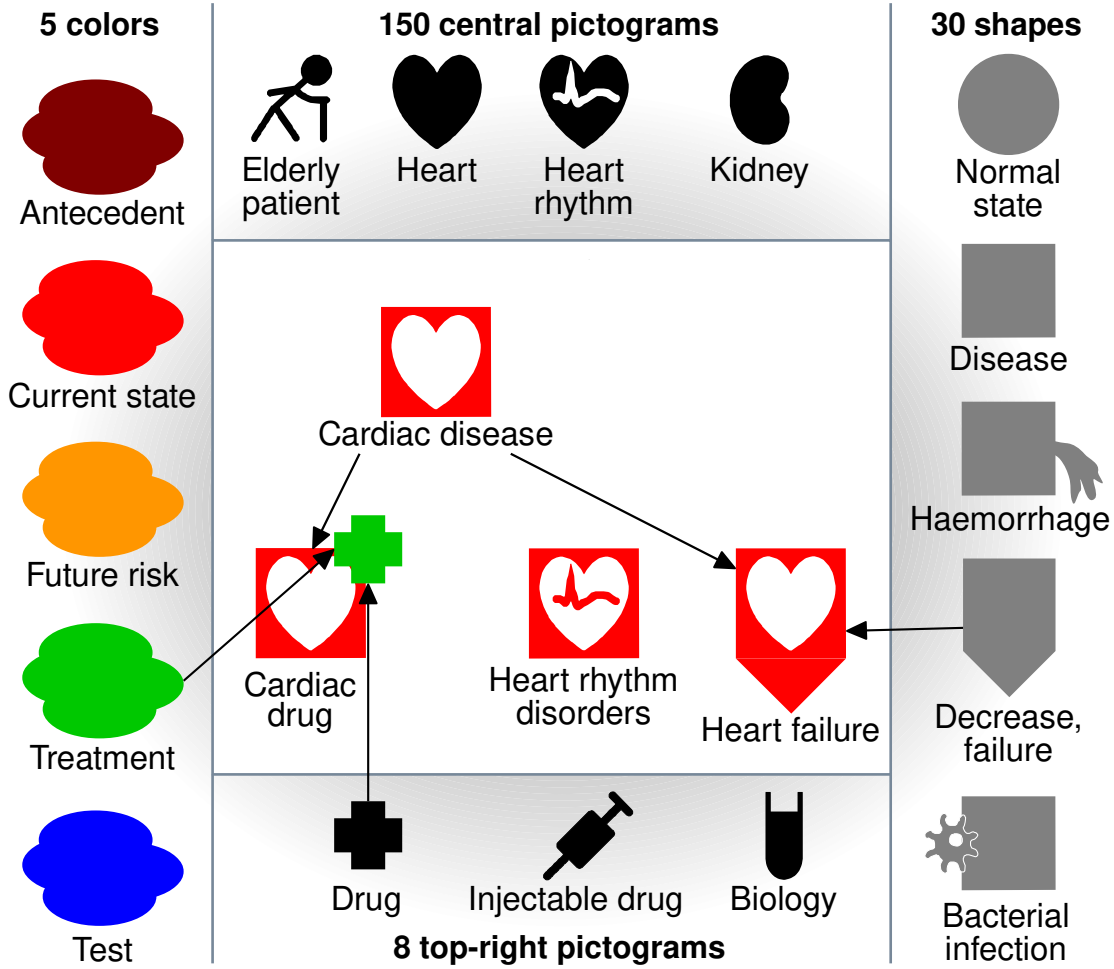

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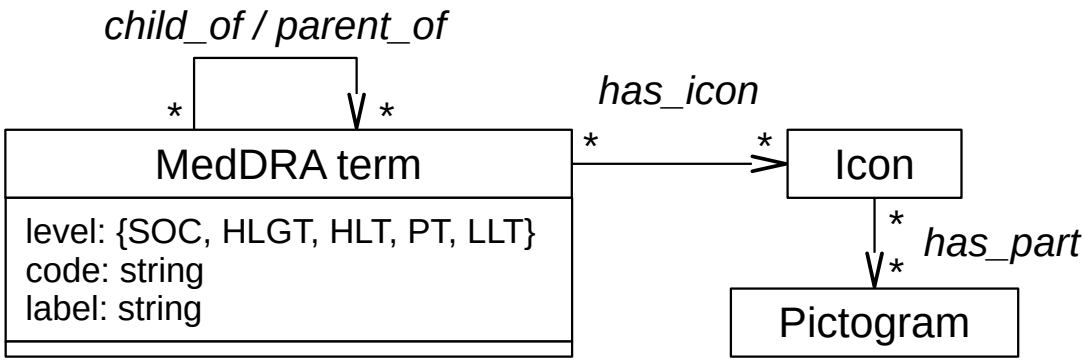
Methods:
Model mapping MedDRA to VCM

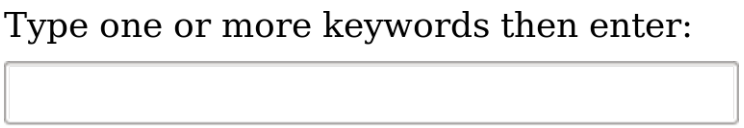
- **OWL ontology including:**
  - ~70,000 MedDRA terms and ~2,400 VCM icons
  - ~530,000 RDF triples (46 Mb)
  - $\mathcal{ALIF}(D)$ description logics family
- **MedDRA to VCM mapping [MIE 2018]**
- **Designed with Owlready ontology-oriented programming module**
  - Translate the ontology to an SQL database
  - Support full-text search



French Book available on Owlready!

Methods:
Search strategies

- **Lexical search**
  - Search with one or more keywords
  - Auto-completion
  - Uses Owlready / SQLite3 implementation



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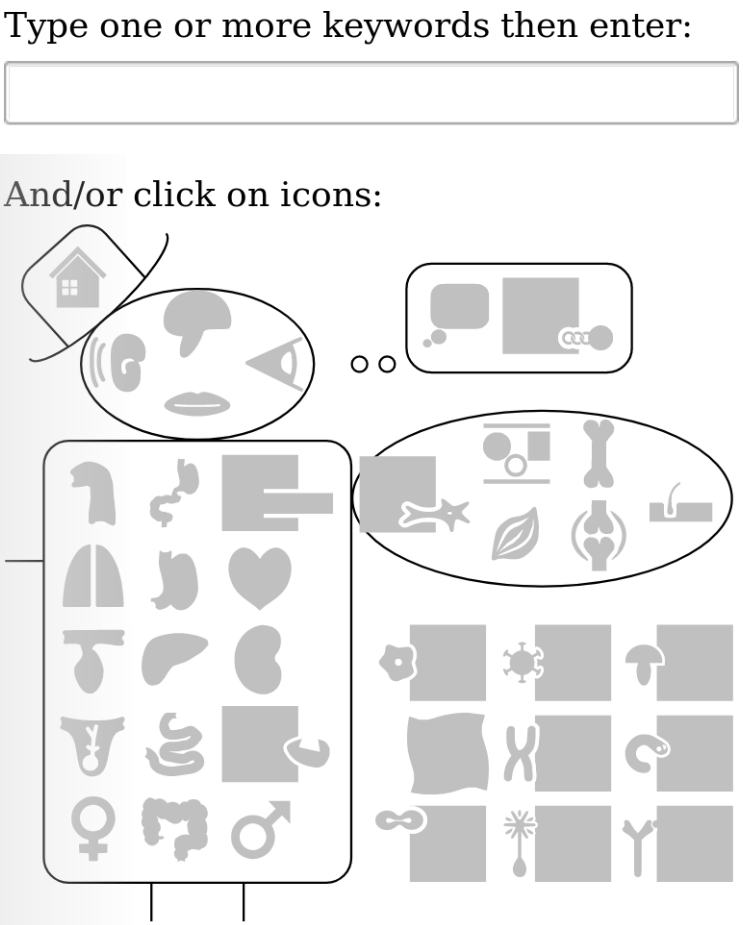
- **Iconic search**
  - Select one or more pictograms
  - From the 37 most generic pictograms in VCM
  - Organized on “Mister VCM”, an anatomical schema
  - If several pictograms are selected, their intersection is considered



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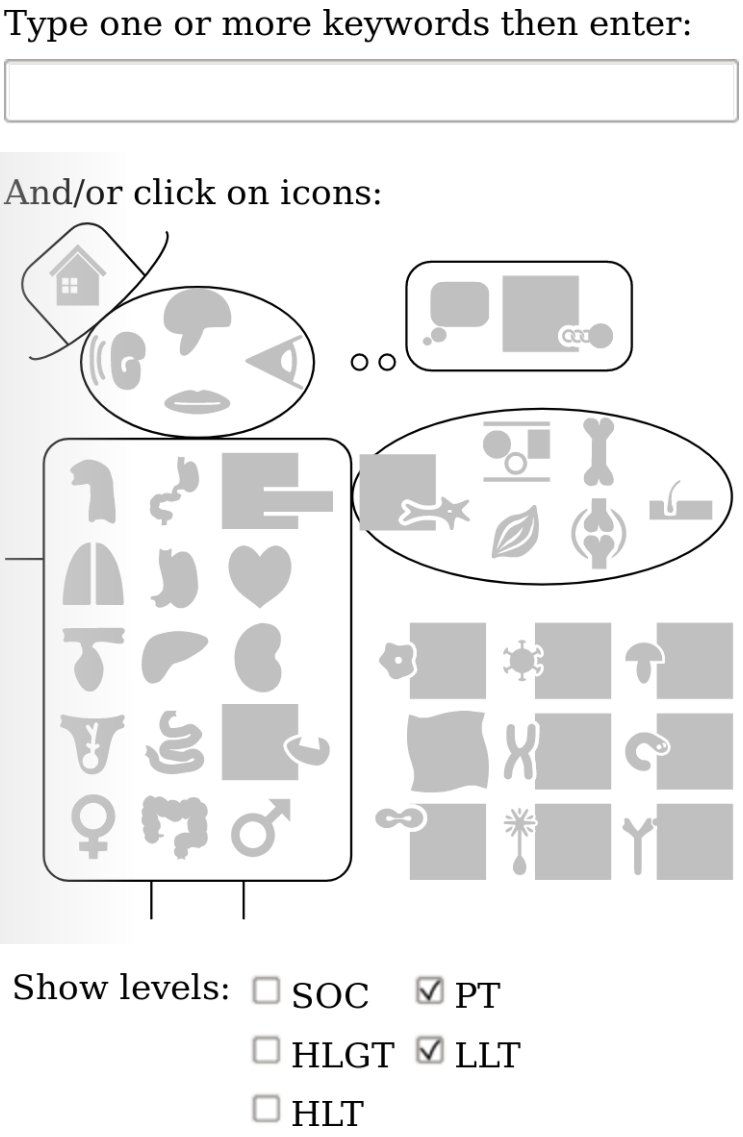
- **Hierarchical search**
  - Limited to the ability to filter by depth
  - 5 depth levels in MedDRA



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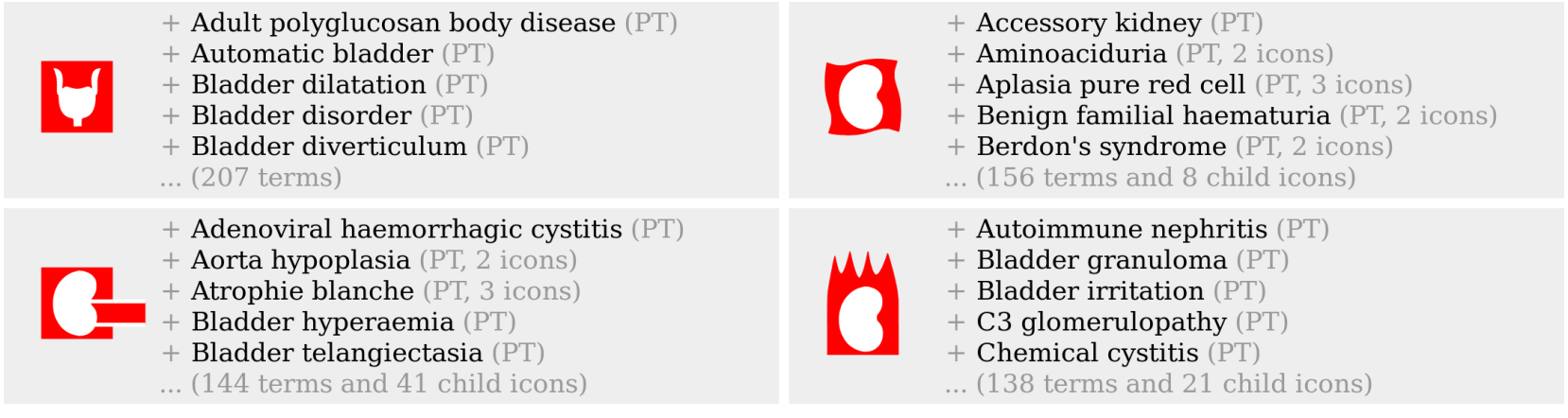
The 3 strategies can be used alone or in combination, in any order

Methods: Search algorithm

function lexico_icono_hierarchical_search(keywords, pictograms, selected_levels):
    if only keywords (*i.e.* pictograms = ∅):
        terms = { t **such that** MedDRA(t) **and** match(t.label, keyword) **and** t.levels ∈ selected_levels }
        icons = { i **such that** Icon(i) **and** ∃ t ∈ terms **with** has_icon(t, i) }
    else if only pictograms (*i.e.* keywords = ∅):
        icons = { i **such that** Icon(i) **and** ∀ p ∈ pictograms **we have** has_part(i, p) }
        terms = { t **such that** MedDRA(t) **and** t.levels ∈ selected_levels **and** ∃ i ∈ icons **with** has_icon(t, i) }
        icons = { i **such that** i ∈ icons **and** ∃ t ∈ terms **with** has_icon(t, i)}
    else (both keywords and pictograms):
        terms = { t **such that** MedDRA(t) **and** match(t.label, keyword) **and** t.levels ∈ selected_levels }
        icons = { i **such that** Icon(i) **and** ∀ p ∈ pictograms **we have** has_part(i, p) }
        terms = { t **such that** t ∈ terms **and** ∃ i ∈ icons **with** has_icon(t, i) }
        icons = { i **such that** i ∈ icons **and** ∃ t ∈ terms **with** has_icon(t, i)}
    return (icons, terms)

Methods: Display of the search results

- **Search results are often numerous!**
  - => Use VCM Icons to organize them
- **Icons associated with the retrieved MedDRA terms are displayed**
  - Icons are sorted by number of terms
  - At most 5 terms are displayed per icons
    - Click on them to display the entire list
  - Icons are grouped according to inheritance rules in VCM
    - *e.g.* Icon for “renal blood vessel occlusion” is grouped under icon for “renal circulation”



Results

- **Good performances**
  - < 0,6 seconds (on a local server, online demo is slower)

- **Demo!**

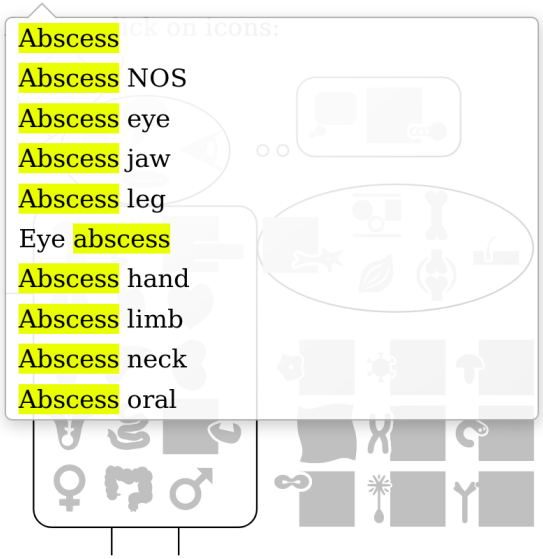
  http://www.lesfleursdunormal.fr/appliweb/vcm/pegase_interface?lang=en

Example of a search combining keywords, icons and depth levels:

Type one or more keywords then enter:

abscess

Abscess
Abscess NOS
Abscess eye
Abscess jaw
Abscess leg
Eye abscess
Abscess hand
Abscess limb
Abscess neck
Abscess oral



Show levels:
- [ ] SOC
- [ ] HLGT
- [ ] HLT
- [x] PT
- [x] LLT

331 MedDRA terms found:

+ Amoebic brain abscess (PT)
+ Bacterial abscess central nervous system (PT)
+ Brain abscess (PT)
+ Central nervous system abscess (PT)
+ Dural abscess (PT)
... (39 terms and 5 child icons)

+ Abscess (PT)
+ Abscess limb (PT)
+ Abscess rupture (PT)
+ Abscess soft tissue (PT)
+ Abscess sterile (PT)
... (38 terms)

+ Bartholin's abscess (PT)
+ Breast abscess (PT)
+ Clitoris abscess (PT)
+ Fallopian tube abscess (PT)
+ Genital abscess (PT)
... (35 terms and 9 child icons)

+ Abscess sweat gland (PT)
+ Periumbilical abscess (PT)
+ Subcutaneous abscess (PT)
+ Abscess apocrine gland (LLT)
+ Abscess of external ear (LLT)
... (33 terms and 4 child icons)

+ Abscess drainage (PT)
+ Abscess management (PT)
+ Abdominal wall abscess drainage (LLT)
+ Abscess breast drainage (LLT)
+ Abscess cavity curettage (LLT)
... (33 terms)

+ Abscess intestinal (PT, 2 icons)
+ Anal abscess (PT)
+ Appendiceal abscess (PT)
+ Colonic abscess (PT)
+ Douglas' abscess (PT, 3 icons)
... (27 terms and 3 child icons)

+ Abscess oral (PT)
+ Gingival abscess (PT)
+ Nasal abscess (PT)
+ Peritonsillar abscess (PT)
+ Pharyngeal abscess (PT)
... (26 terms and 4 child icons)

+ Abdominal abscess (PT)
+ Abdominal wall abscess (PT)
+ Abscess intestinal (PT, 2 icons)
+ Douglas' abscess (PT, 3 icons)
+ Mesenteric abscess (PT, 2 icons)
... (20 terms)

+ Perinephric abscess (PT)
+ Renal abscess (PT)
+ Urachal abscess (PT)
+ Ureter abscess (PT)
+ Urethral abscess (PT)
... (17 terms and 3 child icons)

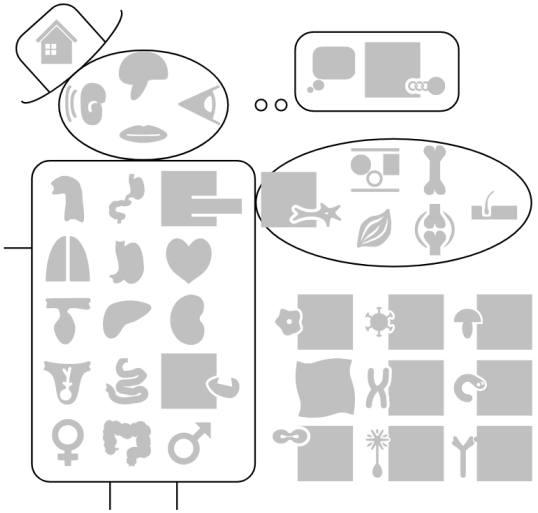
+ Biliary abscess (PT)
+ Gallbladder abscess (PT)
+ Hepatosplenic abscess (PT, 2 icons)
+ Liver abscess (PT)
+ Perihepatic abscess (PT, 3 icons)
... (13 terms and 3 child icons)

Example of a search combining keywords, icons and depth levels:

Type one or more keywords then enter:

abscess

And/or click on icons:



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← Back **17 MedDRA terms found:** +++

+ Abscess kidney (LLT)
+ Abscess perinephric (LLT)
+ Peri-nephric abscess (LLT)
+ Peri-nephric abscess NOS (LLT)
+ Perinephric abscess (PT)
+ Renal abscess (PT)
+ Renal abscess NOS (LLT)
+ Renal and perinephric abscess (LLT)
+ Urachal abscess (PT)
+ Urinary tract abscess (PT)

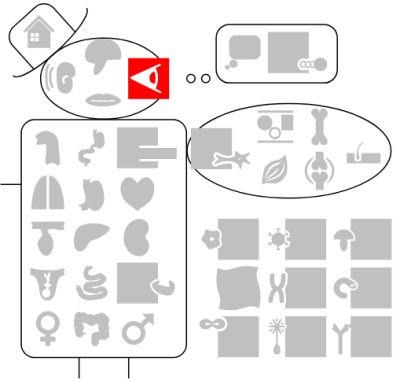
+ Peri-urethral abscess (LLT)
+ Peri-urethral abscess NOS (LLT)
+ Skene's duct abscess (LLT)
+ Urethral abscess (PT)
+ Urinary bladder abscess (PT)

+ Ureter abscess (PT)
+ Ureter abscess NOS (LLT)

Example of an iconic search on the eye:

Type one or more keywords then enter:

and/or
Click on icons:



Show levels:
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New search

3650 MedDRA terms found:

AIDS retinopathy (2 icons)
Abnormal sensation in eye
Accommodation disorder
Acquired corneal dystrophy
Acquired lenticonus
... (1059 terms)

Abducent nerve operation
Acquired epiblepharon
Acute haemorrhagic conjunctivitis (2 icons)
Adenoviral conjunctivitis
Anomaly of orbit, congenital
... (767 terms and 25 child icons)

Acute haemorrhagic conjunctivitis (2 icons)
Anterior chamber angle neovascularisation
Anterior segment ischaemia
Arteriosclerotic retinopathy
Choroidal effusion
... (312 terms and 15 child icons)

Abscess of eyelid
Acanthamoeba keratitis
Acute haemorrhagic conjunctivitis (2 icons)
Adenoviral conjunctivitis
Bacterial blepharitis
... (293 terms and 23 child icons)

Blindness traumatic (2 icons)
Bowman's membrane injury
Cataract operation complication
Cataract traumatic
Chorioretinal scar
... (265 terms and 8 child icons)

Albinism
Alstroem syndrome (2 icons)
Amblyopia congenital (2 icons)
Aniridia
Anomaly of orbit, congenital
... (225 terms and 8 child icons)

Acute myopia
Amaurosis
Amaurosis fugax (2 icons)
Amblyopia
Amblyopia alcohol (2 icons)
... (218 terms and 6 child icons)

Anterior chamber cell
Anterior chamber fibrin
Anterior chamber flare
Anterior chamber inflammation
Aqueous fibrin
... (206 terms and 11 child icons)

Abducent nerve operation
Amblyopia therapy
Bioptic eye surgery
Blepharectomy
Blepharoplasty
... (170 terms and 9 child icons)

Benign neoplasm of choroid
Benign neoplasm of conjunctiva
Benign neoplasm of cornea
Benign neoplasm of eye
Benign neoplasm of eyelid
... (150 terms and 19 child icons)

Angiogram retina
Angiogram retina abnormal
Biopsy cornea
Biopsy cornea abnormal
Biopsy eyelid
... (137 terms and 9 child icons)

Angle closure glaucoma
Borderline glaucoma
Developmental glaucoma
Diabetic glaucoma (2 icons)
Exfoliation glaucoma
... (79 terms)

Anterior capsule contraction
Anterior chamber collapse
Capsular block syndrome
Cataract operation complication
Ciliary zonular dehiscence
... (65 terms and 11 child icons)

Autoimmune retinopathy
Autoimmune uveitis
Birdshot chorioretinopathy
Neuromyelitis optica spectrum disorder
Ocular pemphigoid
... (39 terms and 6 child icons)

Allergic keratitis
Atopic cataract
Atopic keratoconjunctivitis
Blepharitis allergic (2 icons)
Conjunctivitis allergic
... (33 terms and 3 child icons)

Alport's syndrome (3 icons)
Blau syndrome (3 icons)
Carney complex (4 icons)
Congenital optic nerve anomaly
Cri du Chat syndrome (2 icons)
... (30 terms and 4 child icons)

Eye pain
Eyelid pain
Aching eye socket
Blepharal pain
Dull eye pain
... (28 terms)

Acquired pigmented retinopathy
Amblyopia alcohol (2 icons)
Amblyopia tobacco
Chemical burns of eye
Chemical eye injury
... (23 terms and 4 child icons)

Albinism
Endocrine ophthalmopathy (2 icons)
Hypercarotinaemia
Kayser-Fleischer ring (2 icons)
Lecithin-cholesterol acyltransferase deficiency
... (15 terms and 3 child icons)

Dark circles under eyes
Device optical issue
Glassy eyes
Immune recovery uveitis
Subacute myelo-opticoneuropathy (2 icons)
... (8 terms and 2 child icons)

Cataract associated with radiation and other physical influences
Cataract radiation
Radiation cataract
Radiation corneal injury
Radiation retinopathy
... (2 child icons)

LIPCOF examination
Lid parallel conjunctival folds examination
Slit-lamp examination
Slit-lamp tests
Slit-lamp tests abnormal

Chronic enlargement of lacrimal gland
Corneal hypertrophy
Lacrimal gland enlargement

Mikulicz's disease (2 icons)
Mikulicz's syndrome (2 icons)

Glaucoma drug therapy

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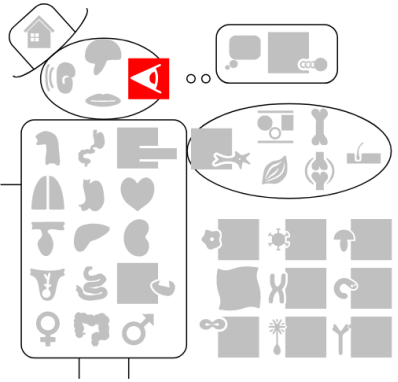

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Exfoliation glaucoma
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Allergic keratoconjunctivitis
Allergic rhinitis due to pollen (2 icons)
Atopic cataract
Atopic keratoconjunctivitis
Birch pollen allergy (2 icons)
Blepharitis allergic (2 icons)
Contact and allergic dermatitis of eyelid (2 icons)
Eye allergy
Grass allergy (2 icons)
Hay fever (2 icons)
Pollen allergy (2 icons)
Pollinosis (2 icons)
Ragweed allergy (2 icons)
Rhinitis seasonal (2 icons)
Seasonal allergic rhinitis (2 icons)
Seasonal allergy (2 icons)
Seasonal conjunctivitis (2 icons)
Seasonal nasopharyngitis (2 icons)

Conjunctivitis allergic
Giant papillary conjunctivitis
Scleritis allergic
Acute atopic conjunctivitis
Allergic blepharoconjunctivitis
... (12 terms)

Oculo-respiratory syndrome (3 icons)
Oculorespiratory syndrome (3 icons)

Allergic keratitis
Atopic cataract
Atopic keratoconjunctivitis
Blepharitis allergic (2 icons)
Conjunctivitis allergic
... (33 terms and 3 child icons)

Click!

Acquired pigmented retinopathy
Amblyopia alcohol (2 icons)
Amblyopia tobacco
Chemical burns of eye
Chemical eye injury
... (23 terms and 4 child icons)

Cataract associated with radiation and other physical influences
Cataract radiation
Radiation cataract
Radiation corneal injury
Radiation retinopathy
... (2 child icons)

Mikulicz's disease (2 icons)
Mikulicz's syndrome (2 icons)

Results

- **Expert opinions**
  - The interface was tested by 2 pharmacovigilance experts
    - Very few pharmacovigilance experts => difficult to recruit
  - Purely iconic search: not so interesting...
  - Combined iconic and lexical search: very interesting for exhaustive searches
    - Can increase the sensibility of the search, because VCM pictograms are broader that keywords
  - “VCM is an Esperanto of medical language”
  - Useful for students and non-experts such as clinical research associates (CRA)
    - *e.g.* VCM icons explicitly represent “cardia” as related to the stomach

Tumor of cardia

Discussion

- **An original approach for browsing and searching medical terminologies**
  - A new application for the VCM iconic language
  - Facilitate exhaustive searches
  - Overview of the terminology
- **Limitations**
  - Requires to map the terminology with VCM
  - Requires to train users in VCM icons
- **In the literature [Massari et al.]**
  - Meta-terms based on medical specialties for facilitating searches
  - But textual and not iconic

Conclusion

- **Icons are a new and promising approach for browsing and searching medical terminologies**
- **Perspectives**
  - Evaluation of the interface in a pharmacovigilance setting
  - Adaptation to other terminologies
    - *e.g.* for coding electronic health records (EHR): ICD10, SNOMED CT
  - Use in medical education

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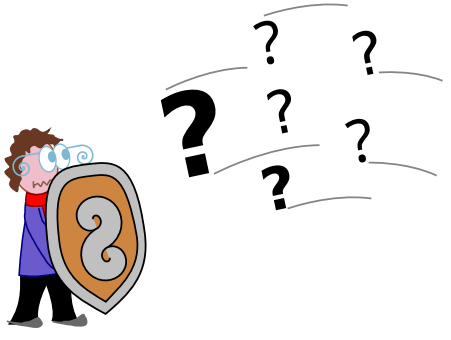

Demo address:
http://www.lesfleursdunormal.fr/appliweb/vcm/pegase_interface?lang=en