SNOMED CT Coding Molecular and Genomic Data for Precision Cancer Medicine

Scott Campbell, MBA, PhD
James Campbell, MD
Kuala Lumpur, Malaysia
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University of Nebraska Medical Center
Nebraska Medicine

Disclosures

1. Dr. W. Scott Campbell and Dr. James R. Campbell partially supported by NIH Award: U01HG009455; Patient Centered Outcomes Research Institute (PCORI) Award CDRN-1306-04631); Funding from UNMC Departments of Pathology and Microbiology and Internal Medicine

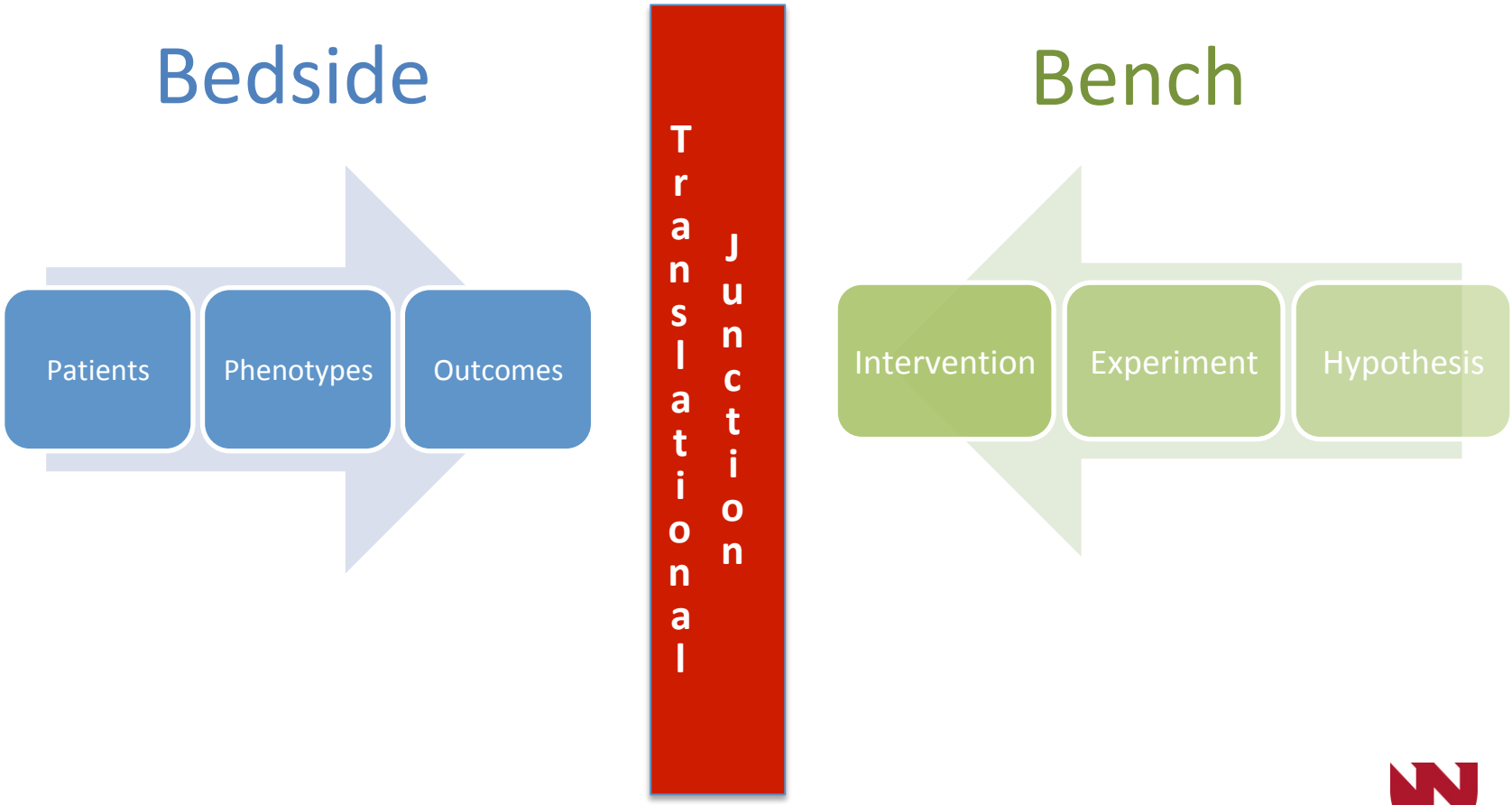
2. GenomOncology has license agreement with UNMC for use of Nebraska Lexicon pathology and genomics content for commercial use. Research use not restricted

Questions that need answers

- Find all patients diagnosed for lower GI adenocarcinoma
- Find all patients with Chronic Kidney Disease subsequently diagnosed with cancer. What is incidence rate at UNMC compared to state and national rates of cancer by type
- Find all cases of lower GI adenocarcinoma with MMR IHC results, MSI testing and any *RAS mutation by pathogenicity. Did these patients receive any gene targeted therapy AND did it followed FDA guidelines
- Find all positive opioid screens in urine or blood performed in ED and “repeat” patient encounters
- Find all bacterial infections in post-transplanted patients, identify frequency by organism, susceptibility patterns, associated treatments and subsequent outcomes

Answers contained in EHR

Primary Data – Bridge the Gap



EHR Data Lake?

Use of clinical terminologies (standards) in a standard way: useful EHR data lakes

Not all data is clean or “good”

Dirty data needs to be cleaned

Characterized (annotated) data is cleaner data

Use Cases

- Histology
- Genomics in cancer
- Laboratory Medicine and Microbiology

Current state – Poetry, prose and PDF

- I: Pancreatic resection with adherent duodenal resorption (measuring 11 cm), ventricular resorption (measuring approximately 5 cm), and gall bladder, macroscopic u a. Pancreatic resection approximately 8 x 4 cm, with a 3 x 3 cm tumor, cut and chopped and constricted choledochus and pancreatic cancer.
- Histologically, the corresponding tumor, infiltratively growing atypical gland formations, is seen. Cylindrical gland epithelium with nuclear stratification, enlarged hyperchromatic cell nuclei and mitosis. Central tumor necrosis. Picture as in medium differentiated adenocarcinoma. Macroscopically and with taken histological cuts, radically excited with narrow but free margin against the retinal vena porta. (B). The medi preparation contains a reactive lymph node.

Examples – Courtesy of Carlos Fernandez Moro, Karolinska Institute

- I (1): 7.7 cm ventricle with … until the papilla. Continuous 8.5 x 2.5 cm gallbladder. 2.5 x 3 x 2 cm yellow-white tumor-like change, growing partially in the pancreatic head against the duodenal mucosa and choledochus and papilla vateri.
- The ventricular free ducts, duodenum, leftover pancreatic tissue and choledochus without detectable tumor growth. In the gall bladder, microscopic focal hyperplastic mucosa and signs of chronic cholecystitis with lymphocytic infiltration are observed. No signs of malignancy in the gall bladder.
- Similar to the macroscopic tumor, a medium to focal low differentiated adenocarcinoma is seen that grows under the duodenal mucosa and into the pancreatic head with large necrotic areas and desmoplastic connective tissue formation. …comprised of major tubular formations, means that one should primarily suspect the outcome of proximal choledochus or pancreatic cancer. Biggest tumor size 2.5 x 2.2 cm. Distance to the nearest travel area 1.6 cm.
- In fraction I, 21 tumor-free lymph nodes are found. In addition, two tumor tumors of tumor growth per continuitatem from the tumor.
- T3 N0 MX.

Detected Alterations of Known or Potential Pathogenicity

Gene	Alteration	Type of Alteration	Significance	Therapeutic Implications*	Additional Information	Comments
BRAF	V600E c.1799T>A	Substitution - Missense	Pathogenic	Associated with drug response; Potentially relevant clinical trials	COSMIC: COSM476 Allele Frequency: 0.0% dbSNP: rs113488022	
PIK3CA	Q546R c.1637A>G	Substitution - Missense	Pathogenic	Potentially relevant clinical trials	COSMIC: COSM12459 Allele Frequency: 0.0% dbSNP: rs397517201	This variant was confirmed by dideoxy sequencing on 01/25/2016. This variant has been classified as pathogenic in the ClinVar database from NCBI.

Detected Alterations of Uncertain Significance

Gene	Alteration	Type of Alteration	Significance	Therapeutic Implications*	Additional Information	Comments
None						

Detected Alterations Known to be Benign or Likely to be Benign

Gene	Alteration	Type of Alteration	Significance	Therapeutic Implications*	Additional Information	Comments
KIT	M541L c.1621A>C	Substitution - Missense	Benign	N/A	COSMIC: COSM28026 Allele Frequency: 6.4% dbSNP: rs3822214	This is likely a germline polymorphism.
TP53	P72R c.215C>G	Substitution - Missense	Benign	N/A	COSMIC: COSM250061 Allele Frequency: 54.3% dbSNP: rs1042522	This is likely a germline polymorphism.

***Therapeutic Implications:** Associated with drug response = related to drug sensitivity or resistance as described in Drug Response section of this report; Potentially relevant clinical trials = gene is related to a trial in the Clinical Trials section of this report
COSMIC: Mutation ID in the Catalogue Of Somatic Mutations in Cancer (http://cancer.sanger.ac.uk/)
Allele Frequency: Allele frequency of the alteration in the 1000 Genomes Project (http://www.1000genomes.org/)
dbSNP: RS number of alteration in dbSNP database (http://www.ncbi.nlm.nih.gov/SNP)

What *Do* we have available

Format/content

- CAP Cancer Checklists, other synoptic forms
- Variety of molecular reporting styles

Data and encoding

- Structured data (local data stores)
- ICD-O-3 (Taxonomic…limited aggregation)
- LOINC (Limited content, no aggregation, limited definition)
- SNOMED CT (Content but poorly defined)
- Natural Language Processing (NLP) (Accurate?; do once maybe)

Histopathology Reporting Evolution

Level 1 - Narrative	Level 2 – Narrative with required data elements	Level 3 – Narrative with required data elements in Synoptic format	Level 4 – Level 3 plus electronic user interface for data entry	Level 5 – Level 4 plus structured language and discrete data capture	Level 6 – Level 5 plus all data encoded in machine readable, standard terminology

Level 7- Semantic interoperability

1. Srigley JR, McGowan T, Maclean A, Raby M, Ross J, Kramer S, et al. Standardized synoptic cancer pathology reporting: a population-based approach. J Surg Oncol. 2009 Jun 15;99(8):517-24.

Historical Efforts

Reporting Pathology Protocols (2005; 2009)

- CDC funded
- Neither LOINC nor SNOMED CT provided sufficient context to separate the data elements from the worksheet for analysis
- Creation of C-keys by CAP (Indexed data elements by worksheet)

- SNOMED: 371441004 |Histologic type (observable entity)|
  - No definition
  - Breast lesion? Colorectal? Malignant? Benign?

- LOINC: No content (<100 concepts developed *circa* RPP studies)

1. Centers for Disease Control and Prevention (CDC). Report on the Reporting Pathology Protocols for Breast and Prostate Cancers, and Melanomas. Atlanta: U.S. Department of Health and Human Services; 2009 July 4, 2009. Report No.: RPP2.

2. Centers for Disease Control and Prevention (CDC). Report on the Reporting Pathology Protocols for Colon and Rectum Cancers Project. Atlanta: U.S. Department of Health and Human Services; 2005 December 16, 2005. Report No.: RPP1.

What is needed to answer these questions?

1. Consistent framework for data capture and transport
   - CAP cancer worksheets (and other professional groups tissue pathways) provide framework,
   - Not enough by itself

2. Useful, navigable (semantic) encoding
   - How are data elements represented such that they are useful internally to your institution AND externally
     - (Transitions of care; Registries, research; Intersection with knowledge bases)
   - Path poetry and Pretty pdfs are great for the first read;
     - Lousy after that – lost to follow up, media tab, NOT computable
     - NLP *can* help but needs to be linked with computer readable terminology

Current Effort

Started in 2014

CAP, US NLM, SNOMED International, UK eHealth

Use SNOMED CT and harmonized observables concept model (LOINC/SNOMED CT cooperative agreement)

Encode all CAP (and now ICCR) synoptic worksheets

Biomarkers included

How

SNOMED International/RII cooperative agreement

Observables “ontology” or concept model

- How things relate to other things

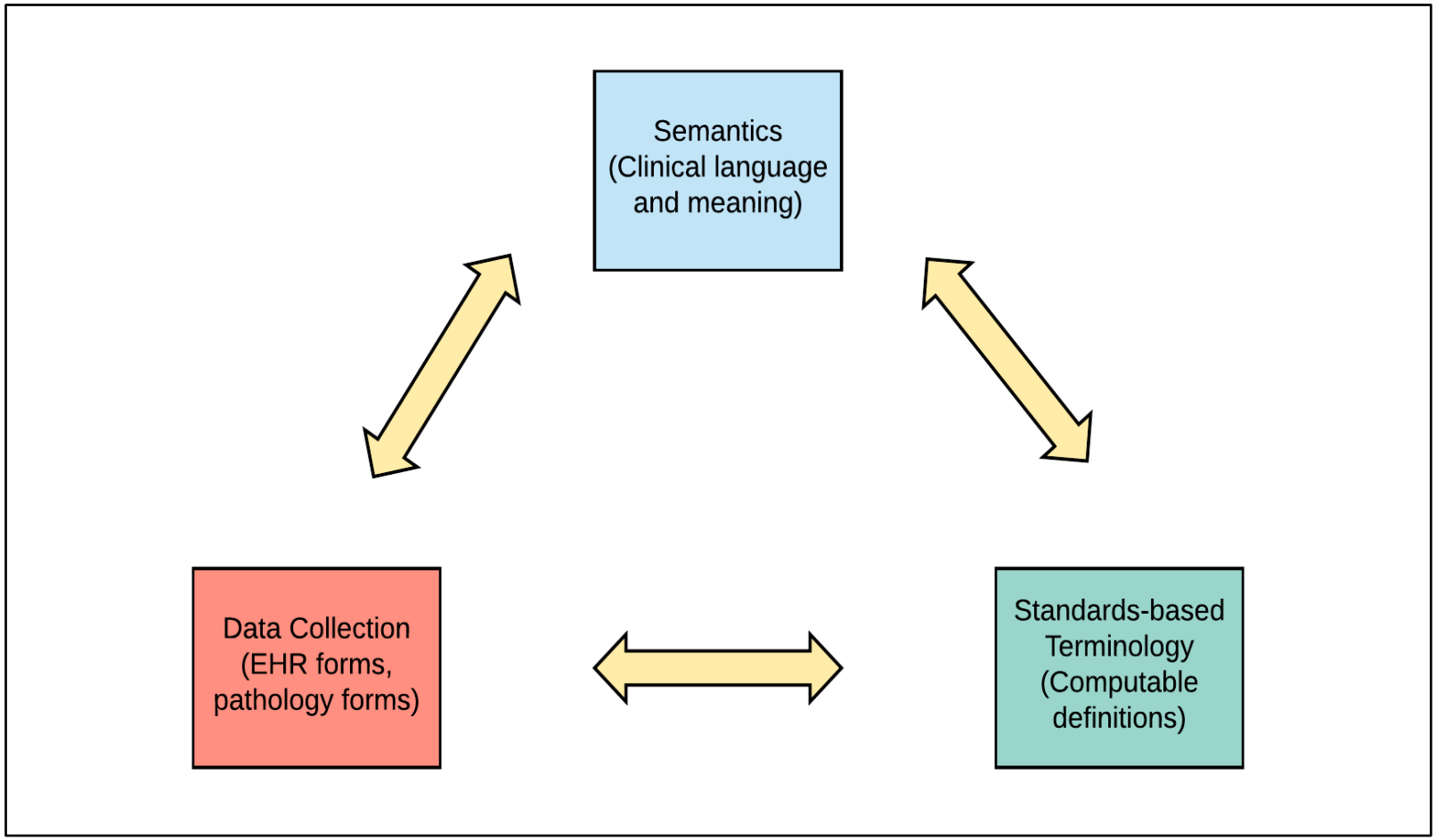
Develop, test and harden using SNOMED extension

- Nebraska Lexicon – namespace ID 1000004

Collaborative efforts with terminologists, pathologists

- CAP; RCPath; ICCR; RCPA; Swedish Society of Pathology
- Canada, US, UK, Australia, Sweden

Terminology Development Triangle



Histologic type of malignant neoplasm of colon

Summary | Details | Diagram | Expression | Refsets | Members | References

Parents

- Tumor observable (observable entity)
- Histologic feature of tumor (observable entity)
  - Tumor observable (observable entity)
  - Histologic type of tumor (observable entity)
    - Histologic type of malignant neoplasm (observable entity)
      - Histologic type of primary malignant neoplasm (observable entity)

Histologic type of primary malignant neoplasm of colon (observable entity)

SCTID: 798721000004104

798721000004104 | Histologic type of primary malignant neoplasm of colon (observable entity) |

en Histologic type of primary malignant neoplasm of colon

Technique → Anatomic pathology technique
Inherent location → Colon structure
Property → Histologic type
Inheres in → Malignant neoplasm, primary
Scale type → Nominal value
Time aspect → Single point in time

How these concepts relate to one another

SNOMED CT supports aggregation

- Find all Lower GI malignant tumors captures: Large intestine and all substructures, Small intestine and all substructure, rectum, anus

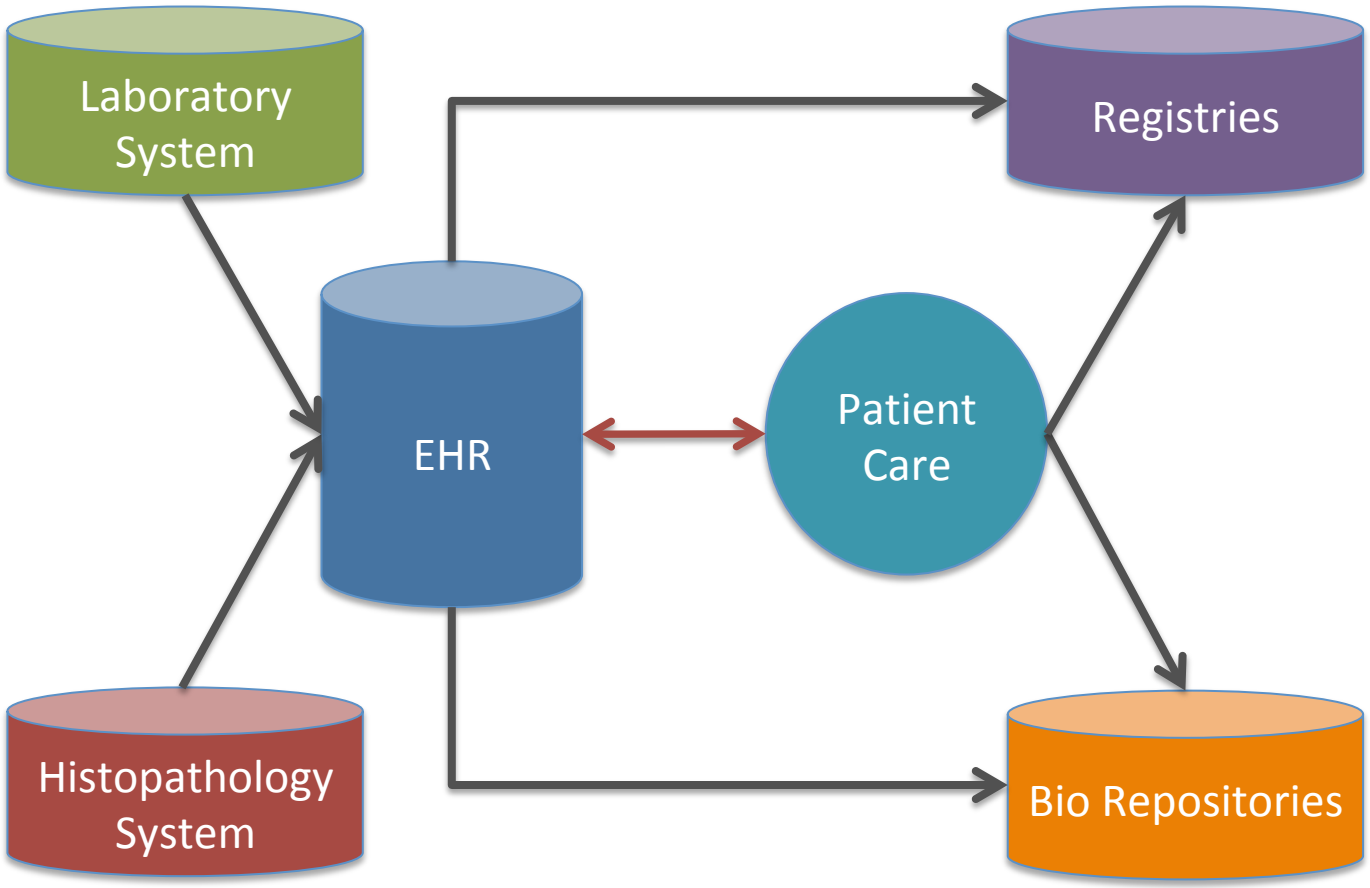
How concepts relate to one another in SNOMED CT

- Find all observations made on the ERBB2 gene captures: IHC for HER2; FISH for HER2; NGS for ERBB2

SNOMED CT uses defining relationships to link concepts

- Hierarchically
- Definitional

Incorporation in Workflow



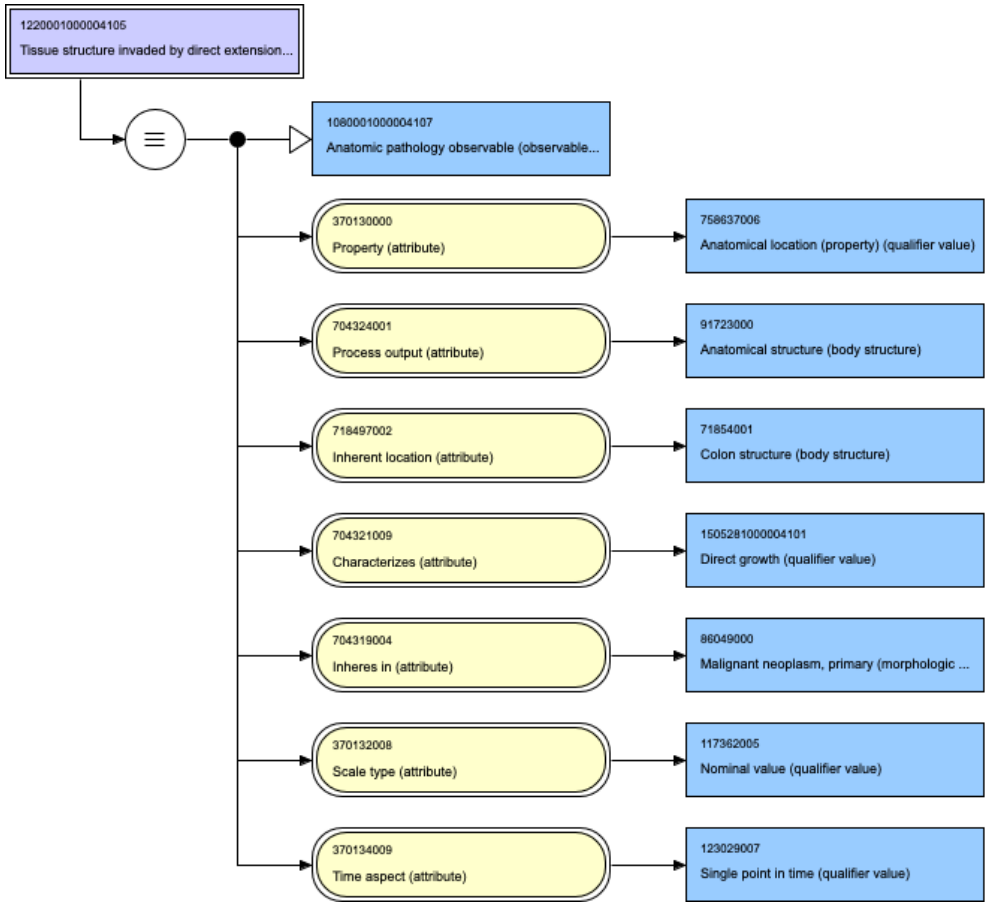
Example: Microscopic invasion by colon tumor

CAP Approved

Microscopic Tumor Extension

___ Cannot be assessed
___ No evidence of primary tumor
___ No invasion (high-grade dysplasia/intraepithelial carcinoma)
___ Tumor invades lamina propria/muscularis mucosae (intramucosal
___ Tumor invades submucosa
___ Tumor invades muscularis propria
___ Tumor invades through the muscularis propria into the subserosal pericolic or perirectal soft tissues but does not extend to the seros
___ Tumor penetrates to the surface of the visceral peritoneum (serosa
___ Tumor is adherent to other organs or structures (specify: _____
___ Tumor directly invades adjacent structures (specify: _____
___ Tumor penetrates to the surface of the visceral peritoneum (serosa (specify: _____)

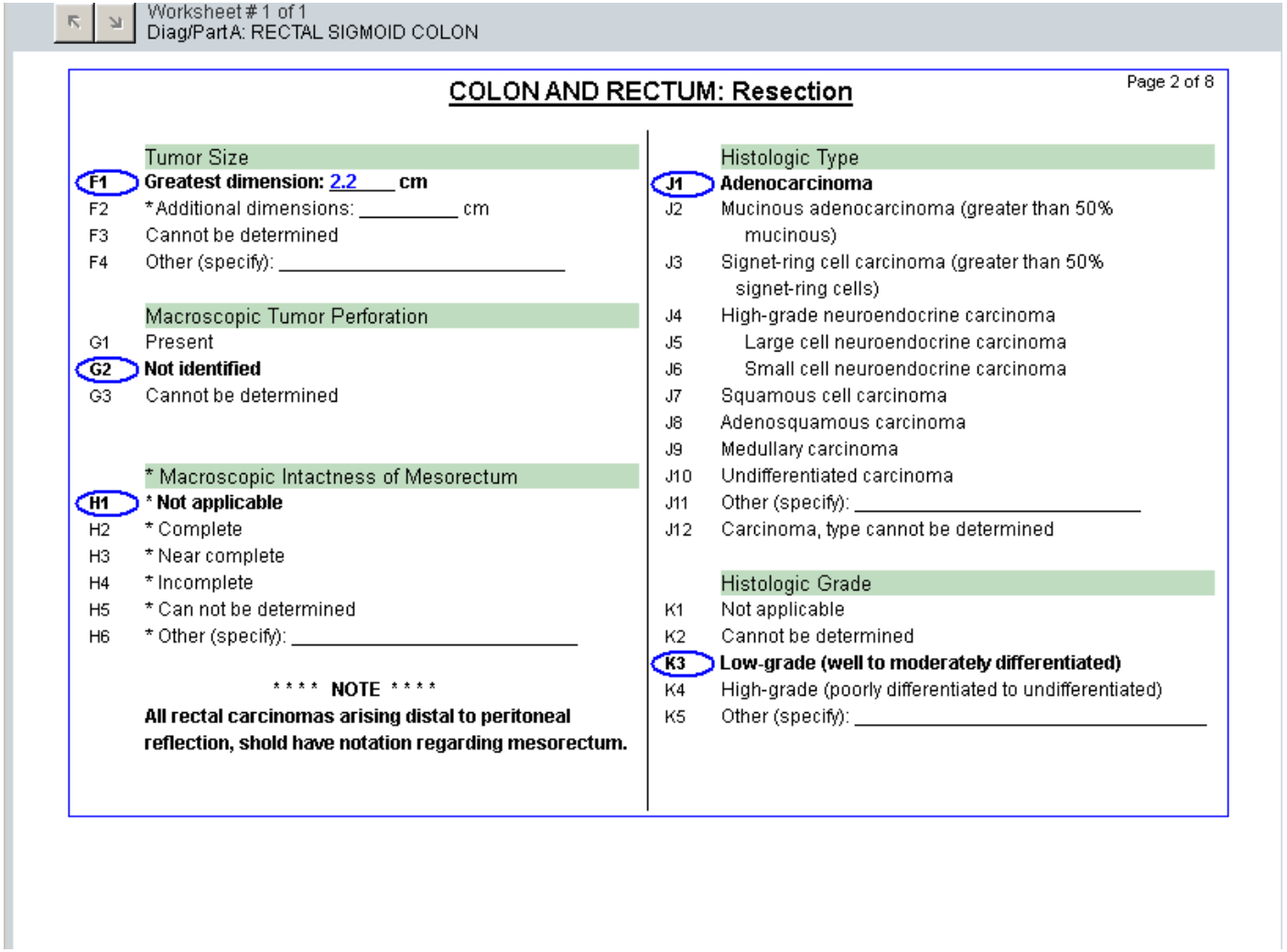
SNOMED CT –
Tissue structure invaded by direct extension of primary malignant neoplasm of colon



Example Value set

Direct extension of colon tumor	1220001000004105 |Tissue structure invaded by direct extension of primary malignant neoplasm of colon (observable entity)|		
Value set of answers		Tumor invasion cannot be assessed	460831000004104|Body structure without current definition (body structure)
		Carcinoma in situ, intraepithelial	42978003 | Colonic epithelium (body structure) |
		Carcinoma in situ, invasion of lamina propria	113284008 | Colonic lamina propria (body structure) |
		Tumor invades submucosa	61647009 | Colonic submucosa (body structure) |
		Tumor invades muscularis propria	41948009 | Colonic muscularis propria structure (body structure) |
		Tumor invades through the muscularis propria into the subserosa or into non-peritonealized pericolic or perirectal tissue	52010009 | Colonic subserosa (body structure) |
		Tumor penetrates serosa	90132000 | Colonic serosa (body structure) |

Implementation - Terms Bound to CoPath® for Pathologist



Worksheet # 1 of 1
Diag/Part A: RECTAL SIGMOID COLON

COLON AND RECTUM: Resection

Page 2 of 8

Tumor Size

F1 **Greatest dimension: 2.2 cm**
F2 *Additional dimensions: _____ cm
F3 Cannot be determined
F4 Other (specify): _____

Macroscopic Tumor Perforation

G1 Present
G2 **Not identified**
G3 Cannot be determined

*** Macroscopic Intactness of Mesorectum**

H1 *** Not applicable**
H2 * Complete
H3 * Near complete
H4 * Incomplete
H5 * Can not be determined
H6 * Other (specify): _____

****** NOTE ******

All rectal carcinomas arising distal to peritoneal reflection, shold have notation regarding mesorectum.

Histologic Type

J1 **Adenocarcinoma**
J2 Mucinous adenocarcinoma (greater than 50% mucinous)
J3 Signet-ring cell carcinoma (greater than 50% signet-ring cells)
J4 High-grade neuroendocrine carcinoma
J5 Large cell neuroendocrine carcinoma
J6 Small cell neuroendocrine carcinoma
J7 Squamous cell carcinoma
J8 Adenosquamous carcinoma
J9 Medullary carcinoma
J10 Undifferentiated carcinoma
J11 Other (specify): _____
J12 Carcinoma, type cannot be determined

Histologic Grade

K1 Not applicable
K2 Cannot be determined
K3 **Low-grade (well to moderately differentiated)**
K4 High-grade (poorly differentiated to undifferentiated)
K5 Other (specify): _____

Resultant Data Exchange between Information Systems

MSH|^~\&|COPATH|COPATH|EPIC||2017NNNN||ORU^R01||P|2.3.1
PID|1||2529400||NAME^^^||1968NNNN|M||W|ADDRESS||
PV1|1||3BE|||||||||||^NAME|TCE
OBR|1||SNN-NNNN EXAM||||A|^RIGHT COLON|
NNNNNN||||F
OBX|2|CWE|115000100000410 9^Colon-Polyp Type in which invasive carcinoma arose^SCT||61722000^Tubulovillous adenoma^SCT|||||F
OBX|18|CWE|1948311010000 4102^Bio-Results-MSH2-IHC testing for Mismatch Repair (MMR) Proteins^SCT||78295158100000 4109^MSH2: Intact nuclear expression^SCT|||||F

Question

OBX|24|CWE|8900010000041 07^Colon-Histologic type of neoplasm^SCT||35917007^Adenocarcinoma^SCT^M-81403^^SCT2|||colon:84882-0|||F

Answer

Resultant Report (w/ IHC)
(Fully human and machine readable)

MICROSCOPIC TUMOR CHARACTERISTICS

Histologic type of neoplasm:	Mucinous adenocarcinoma (greater than 50% mucinous)
Histologic grade of neoplasm:	Low-grade (well to moderately differentiated)
Mucinious histologic fraction of neoplasm:	(%): 95
Percent signet ring cells in adenocarcinoma:	(%): 0
Intratumoral Lymphocytic Response:	None
Peritumoral Lymphocytic Response:	None
Status of tumor budding in carcinoma:	None
Number of tumor buds per HPF (Average per 10 HPF):	Average # per HPF: 0
Perineural Invasion:	Perineural invasion absent
Lymphatic (Small Vessel) Invasion (L):	Absent
Intramural vascular (Large vessel) invasion:	Absent
Extramural vascular (Large vessel) invasion:	Absent
Polyp Type in which invasive carcinoma arose:	None identified

ANCILLARY TESTING

Mismatch repair abnormality by IHC:	**No: Mismatch repair proficient**
MLH1- Mismatch Repair (MMR) Proteins by IHC:	Intact nuclear expression
MSH2-Mismatch Repair (MMR) Proteins by IHC:	Intact nuclear expression
MSH6-Mismatch Repair (MMR) Proteins by IHC:	Intact nuclear expression
PMS2-Mismatch Repair (MMR) Proteins by IHC:	Intact nuclear expression
BRAF Expression (by immunohistochemistry):	Negative for cytoplasmic expression

Lower GI Malignancies - Biospecimens

UNMC UNIVERSITY OF NEBRASKA MEDICAL CENTER NECARES

Inventory Reports Orders Checkout Admin Logout

Reports

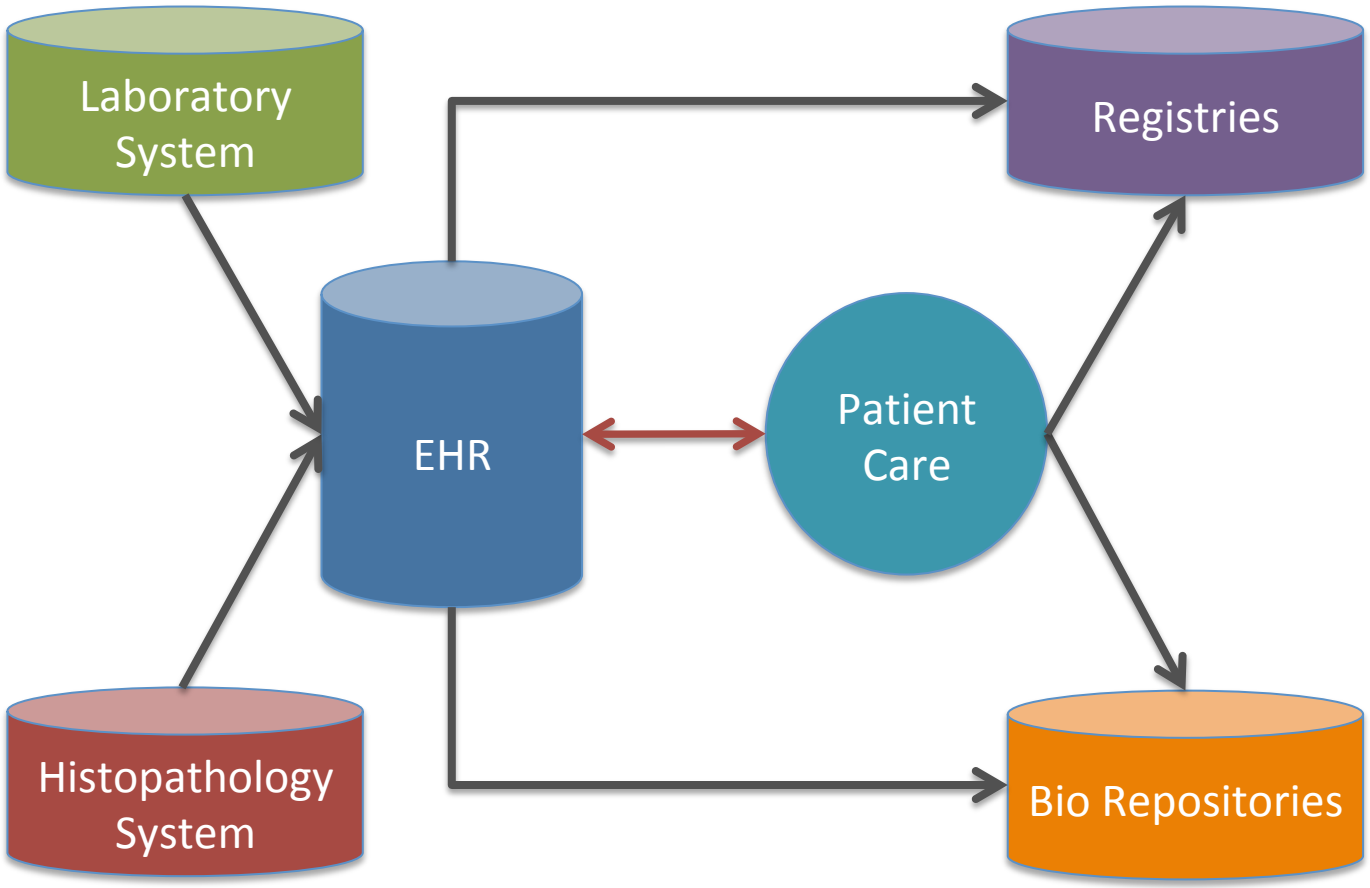
REPORT: LOWER GI MALIGNANCIES													
890001000004107	Histologic type of excised colon neoplasm (observable entity)	72495009	Mucinous adenocarcinoma (morphologic abnormality)	100195	F	57	100195	105278	100907	20170120	430250001	Y	
890001000004107	Histologic type of excised colon neoplasm (observable entity)	72495009	Mucinous adenocarcinoma (morphologic abnormality)	100195	F	57	100195	105278	100899	20170120	309495002	Y	
890001000004107	Histologic type of excised colon neoplasm (observable entity)	72495009	Mucinous adenocarcinoma (morphologic abnormality)	100195	F	57	100195	105278	100898	20170120	309495002	Y	
890001000004107	Histologic type of excised colon neoplasm (observable entity)	72495009	Mucinous adenocarcinoma (morphologic abnormality)	100195	F	57	100195	105278	100904	20170120	430250001	Y	
890001000004107	Histologic type of excised colon neoplasm (observable entity)	72495009	Mucinous adenocarcinoma (morphologic abnormality)	100195	F	57	100195	105278	100903	20170120	430250001	Y	
890001000004107	Histologic type of excised colon neoplasm (observable entity)	72495009	Mucinous adenocarcinoma (morphologic abnormality)	100195	F	57	100195	105278	100895	20170120	309495002	Y	
890001000004107	Histologic type of excised colon neoplasm (observable entity)	72495009	Mucinous adenocarcinoma (morphologic abnormality)	100195	F	57	100195	105278	100896	20170120	309495002	Y	
890001000004107	Histologic type of excised colon neoplasm (observable entity)	72495009	Mucinous adenocarcinoma (morphologic abnormality)	100195	F	57	100195	105278	100897	20170120	309495002	Y	
890001000004107	Histologic type of excised colon neoplasm (observable entity)	72495009	Mucinous adenocarcinoma (morphologic abnormality)	109863	M	85	100433	106087	13228	20170901		Y	
890001000004107	Histologic type of excised colon neoplasm (observable entity)	72495009	Mucinous adenocarcinoma (morphologic abnormality)	100431	M	85	100433	106087	13228	20170901		Y	
911753501000004102	Histologic type of malignant neoplasm of small intestine (observable entity)	128928004	Neuroendocrine neoplasm (morphologic abnormality)	100602	U		100597	101626	100733	20161219	309220004	Y	
911753501000004102	Histologic type of malignant neoplasm of small intestine (observable entity)	128928004	Neuroendocrine neoplasm (morphologic abnormality)	100602	U		100597	101626	100732	20161219	309220004	Y	
911753501000004102	Histologic type of malignant neoplasm of small intestine (observable entity)	128928004	Neuroendocrine neoplasm (morphologic abnormality)	100602	U		100597	101626	100735	20161219	309220004	Y	
911753501000004102	Histologic type of malignant neoplasm of small intestine (observable entity)	128928004	Neuroendocrine neoplasm (morphologic abnormality)	100602	U		100597	101626	100734	20161219	309220004	Y	
911753501000004102	Histologic type of malignant neoplasm of small intestine (observable entity)	128928004	Neuroendocrine neoplasm (morphologic abnormality)	100602	U		100597	101626	100737	20161219	309220004	Y	
911753501000004102	Histologic type of malignant neoplasm of small intestine (observable entity)	128928004	Neuroendocrine neoplasm (morphologic abnormality)	100602	U		100597	101626	100736	20161219	309220004	Y	
911753501000004102	Histologic type of malignant neoplasm of small intestine (observable entity)	128928004	Neuroendocrine neoplasm (morphologic abnormality)	100602	U		100597	101626	100738	20161219	309220004	Y	
911753501000004102	Histologic type of malignant neoplasm of small intestine (observable entity)	418893000	Gastrointestinal stromal tumor - category (morphologic abnormality)	100600	U		100595	101623	100157	20160706	309220004	Y	
911753501000004102	Histologic type of malignant neoplasm of small intestine (observable	418893000	Gastrointestinal stromal tumor - category (morphologic	100600	U		100595	101623	100158	20160706	309220004	Y	

389 rows in 0.401 seconds

CYPHER

COPY CYPHER EXPORT CLOSE

Incorporation in Workflow - Genomics



Molecular pathology report – VERY truncated

Detected Alterations of Known or Potential Pathogenicity						
Gene	**Alteration**	**Type of Alteration**	**Significance**	**Therapeutic Implications***	**Additional Information**	**Comments**
BRAF	V600E c.1799T>A	Substitution - Missense	Pathogenic	Associated with drug response; Potentially relevant clinical trials	COSMIC: COSM476 Allele Frequency: 0.0% dbSNP: rs113488022	
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Detected Alterations of Uncertain Significance						
Gene	**Alteration**	**Type of Alteration**	**Significance**	**Therapeutic Implications***	**Additional Information**	**Comments**
None						

Detected Alterations Known to be Benign or Likely to be Benign						
Gene	**Alteration**	**Type of Alteration**	**Significance**	**Therapeutic Implications***	**Additional Information**	**Comments**
KIT	M541L c.1621A>C	Substitution - Missense	Benign	N/A	COSMIC: COSM28026 Allele Frequency: 6.4% dbSNP: rs3822214	This is likely a germline polymorphism.
TP53	P72R c.215C>G	Substitution - Missense	Benign	N/A	COSMIC: COSM250061 Allele Frequency: 54.3% dbSNP: rs1042522	This is likely a germline polymorphism.

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Allele Frequency: Allele frequency of the alteration in the 1000 Genomes Project (http://www.1000genomes.org/)
dbSNP: RS number of alteration in dbSNP database (http://www.ncbi.nlm.nih.gov/SNP)

Sample intramural HL7 message

OBX|1|CWE|91175254100000410 9^TP53 sequence variant identified in excised malignant neoplasm (observable entity)^SCT|1|
TP53 NP_000537.3:R175H NM_000546.5:c.524G>A^TP53 R175H|||
Pathogenic|||F

Question

OBX|2|CWE|91175211000004101^BRAF sequence variant identified in excised malignant neoplasm (observable entity)^SCT|1|
BRAF NM_004333.4:c.(=)|||Normal|||F

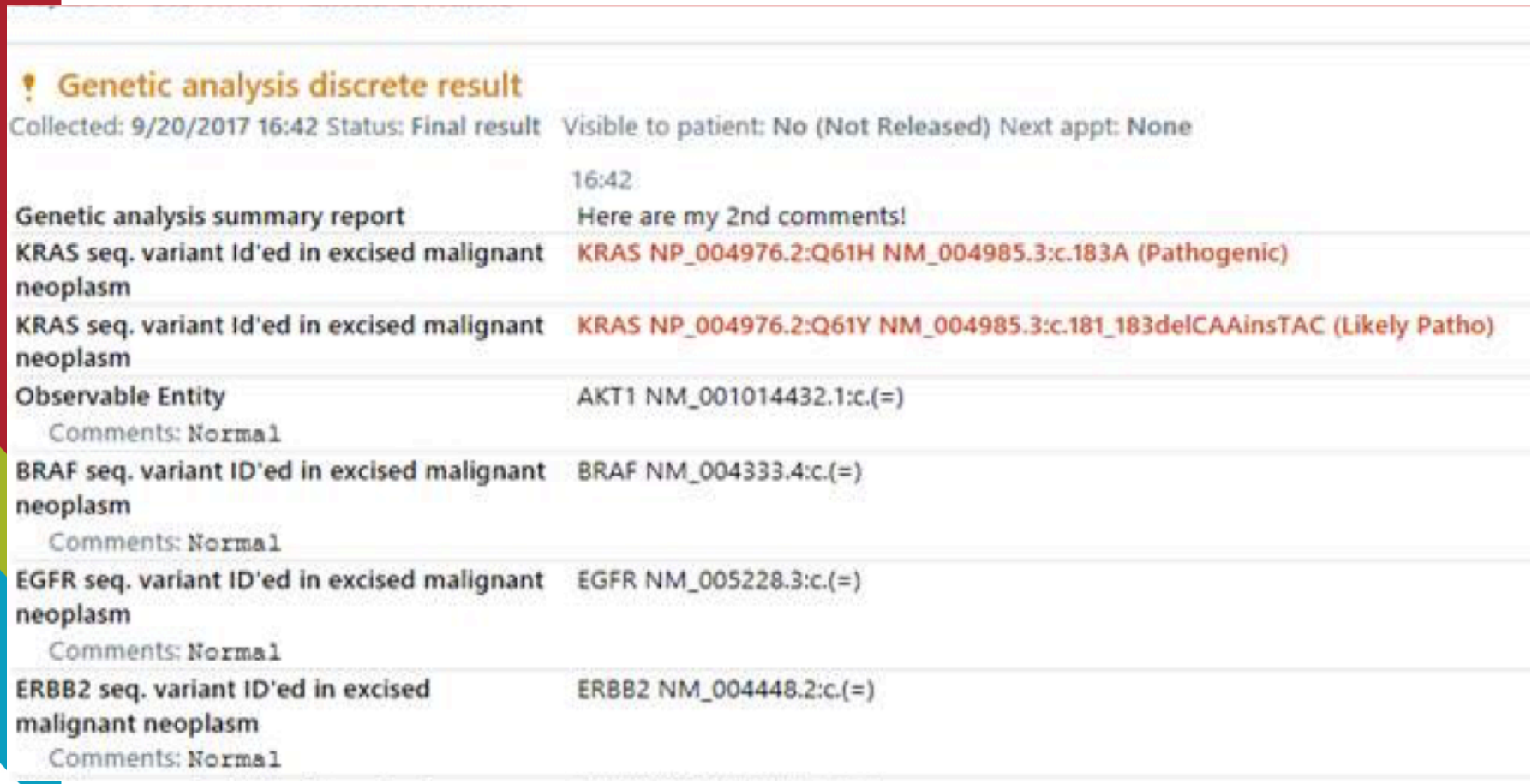
OBX|3|CWE|91175287100000410 2^ASXL1 sequence variant identified in excised malignant neoplasm (observable entity)^SCT|1|ASXL1
NP_056153.2:N986S NM_015338.5:c.2957A>G^ASXL1 N986S||

Answer

|Likely Benign|||F

Pathogenicity

EPIC Clinician View



Genetic analysis discrete result

Collected: 9/20/2017 16:42 Status: Final result Visible to patient: No (Not Released) Next appt: None

	16:42
Genetic analysis summary report	Here are my 2nd comments!
KRAS seq. variant Id'ed in excised malignant neoplasm	KRAS NP_004976.2:Q61H NM_004985.3:c.183A (Pathogenic)
KRAS seq. variant Id'ed in excised malignant neoplasm	KRAS NP_004976.2:Q61Y NM_004985.3:c.181_183delCAAinsTAC (Likely Patho)
Observable Entity Comments: Normal	AKT1 NM_001014432.1:c.(=)
BRAF seq. variant ID'ed in excised malignant neoplasm Comments: Normal	BRAF NM_004333.4:c.(=)
EGFR seq. variant ID'ed in excised malignant neoplasm Comments: Normal	EGFR NM_005228.3:c.(=)
ERBB2 seq. variant ID'ed in excised malignant neoplasm Comments: Normal	ERBB2 NM_004448.2:c.(=)

Genomics Queries – Biospecimen example

```
$ MATCH (a:ObjectConcept) WHERE a.id IN ['890001000004107'] WITH necares.casediag_metadata_find_questions_and_answers(a) AS p0_qa MATCH (a:ObjectConcept) WHERE a.id IN ['911753501000004102'] WITH p0_…
```

Table | Text | Code

PatientDeID	Gender	VariantID	HGVSVariant	Question	Answer
"100195"	"F"	"911752361000004100"	"KRAS NP_004976:G12V NM_004985:c.35G>T"	"Histologic type of excised colon neoplasm (observable entity)"	"Mucinous adenocarcinoma (morphologic abnormality)"
"100195"	"F"	"911752291000004102"	"HRAS NM_005343.2:c.(=)"	"Histologic type of excised colon neoplasm (observable entity)"	"Mucinous adenocarcinoma (morphologic abnormality)"
"100195"	"F"	"911752421000004100"	"NRAS NM_002524.4:c.(=)"	"Histologic type of excised colon neoplasm (observable entity)"	"Mucinous adenocarcinoma (morphologic abnormality)"
"100737"	"F"	"911752421000004100"	"NRAS NM_002524.4:c.(=)"	"Histologic type of excised colon neoplasm (observable entity)"	"Adenocarcinoma, no subtype (morphologic abnormality)"
"100737"	"F"	"911752291000004102"	"HRAS NM_005343.2:c.(=)"	"Histologic type of excised colon neoplasm (observable entity)"	"Adenocarcinoma, no subtype (morphologic abnormality)"
"100737"	"F"	"911752361000004100"	"KRAS NP_004976.2:A146V NM_004985.3:c.437C>T"	"Histologic type of excised colon neoplasm (observable entity)"	"Adenocarcinoma, no subtype (morphologic abnormality)"
"101935"	"M"	"911752421000004100"	"NRAS NM_002524.4:c.(=)"	"Histologic type of excised colon neoplasm (observable entity)"	"Adenocarcinoma, with mucinous features (morphologic abnormality)"
"101935"	"M"	"911752361000004100"	"KRAS NM_004985.3:c.(=)"	"Histologic type of excised colon neoplasm (observable entity)"	"Adenocarcinoma, with mucinous features (morphologic abnormality)"
"101935"	"M"	"911752291000004102"	"HRAS NM_005343.2:c.(=)"	"Histologic type of excised colon neoplasm (observable entity)"	"Adenocarcinoma, with mucinous features (morphologic abnormality)"

Started streaming 9 records after 357 ms and completed after 357 ms.

Ability to link anatomic pathology and molecular pathology

Work to date

SNOMED CT content complete for:

- CRC
- Melanoma
- Invasive Breast Cancer
- Radical Prostatectomy
- IHC biomarkers
- Next Gen Sequencing Observations (~800 named genes)

What is next – work plan

Formal adoption by SNOMED International

- Formally requested by Canada, Sweden and UK

Lung in progress

Gastrointestinal tract

Gynecologic

Done by 12/2019???

Implementation/Propagation (US and Canada)

CAP eCC adopted by most EHR/Path Info Systems (College of American Pathologists, electronic cancer checklist)

CAP SDC framework replacing eCC

- XML document to capture structured data
- Needs the terminology layer to convey context and analytics

CAP and UNMC collaborating to bind developed SNOMED CT content to SDC data elements and distribute as embedded component to SDC

Percent adoption will increase as SDC is ingested/ supported by most US EHR vended systems

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Questions

University of Nebraska Medical Center

Nebraska Medicine