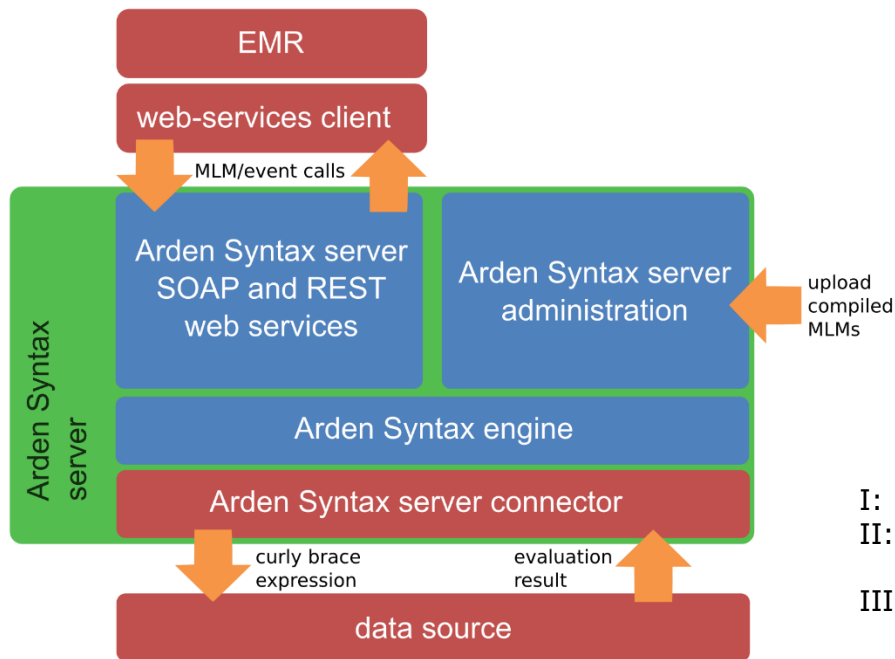


Arden-Syntax-based genuine technology platform for clinical decision support (CDS)



- I: Web services for MLM calling and for data transfer
- II: Web services for MLM calling and server/database connector for data access
- III: Data warehouse + Arden Syntax server = autonomous CDS system

Integration into i.s.h.med at the Vienna General Hospital

Fall/Aufenthalt
 Druckadressaten
 Dokumentstatus
 Externe Ärzte
 Kontaktdaten

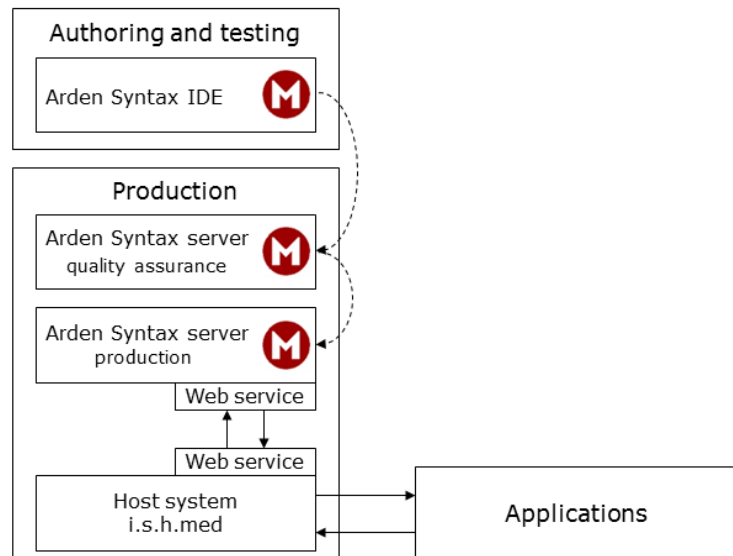
Patient: PatNr.: ████████ Dok.OE: Station 17H
Fall: Gesamter Patient
Bewegung: Gesamter Patient

Schema: SOP Nr. 2 - Dacarbazine 800mg ☒ - in klinischer Validierung

Prä-Chemotherapie Checkliste

Text	Bemerkung	14.04.2011	04.04.2011	31.03.2011
• Verabreichungen			3	
▼ Labor		14.04.2011	04.04.2011	31.03.2011
▼ Blutbild				
• Erythrozyten	> 4.0 T/l	4.1	4	4
• Hämoglobin	> 12.0 g/dl	12.3	12	12
• Leukozyten	> 3.0 G/l	3	3	3
• Thrombozyten	> 100 G/l	105	100	100
▼ Metaboliten				
• Creatinin	< 1.2 mg/dl	1.3	1.2	1.2
▼ Entzündungsparameter				
• CRP	< 1 mg/dl	1	1	1
▼ Allgemeinzustand				
• ECOG State		1	1	1
▼ Wissensbasiertes System		<input type="button" value="Prüfen"/>	<input type="button" value="Prüfen"/>	<input type="button" value="Prüfen"/>
• Empfehlung			akzeptiert	akzeptiert
• Status			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
• Erklärung			<input type="button" value="i"/>	<input type="button" value="i"/>
▼ Sonstiges				
• Bemerkung		<input type="text"/>	<input type="text"/>	<input type="text"/>
• Freigabe				
• Storno				

 - MLMs



University of Colorado Health—with Epic EHR

Arden - Cardiac ICU (7 Patients)

Room/Bed ▲	Patient Name/Age/	Readmit Score	Service	Braden Score	CHADS	Acuity
		37	Cardiology Heart Failure	21	1.05	
		21	Cardiology Heart Failure	17	10	
		10	Cardiology 3	22	0.56	
		18	Cardiology 2	19	21.16	
		5	Cardiology 3	17	0.99	
		9	Cardiology 2	20	10	

Heart failure readmission risk score (HFRRS)

Input:

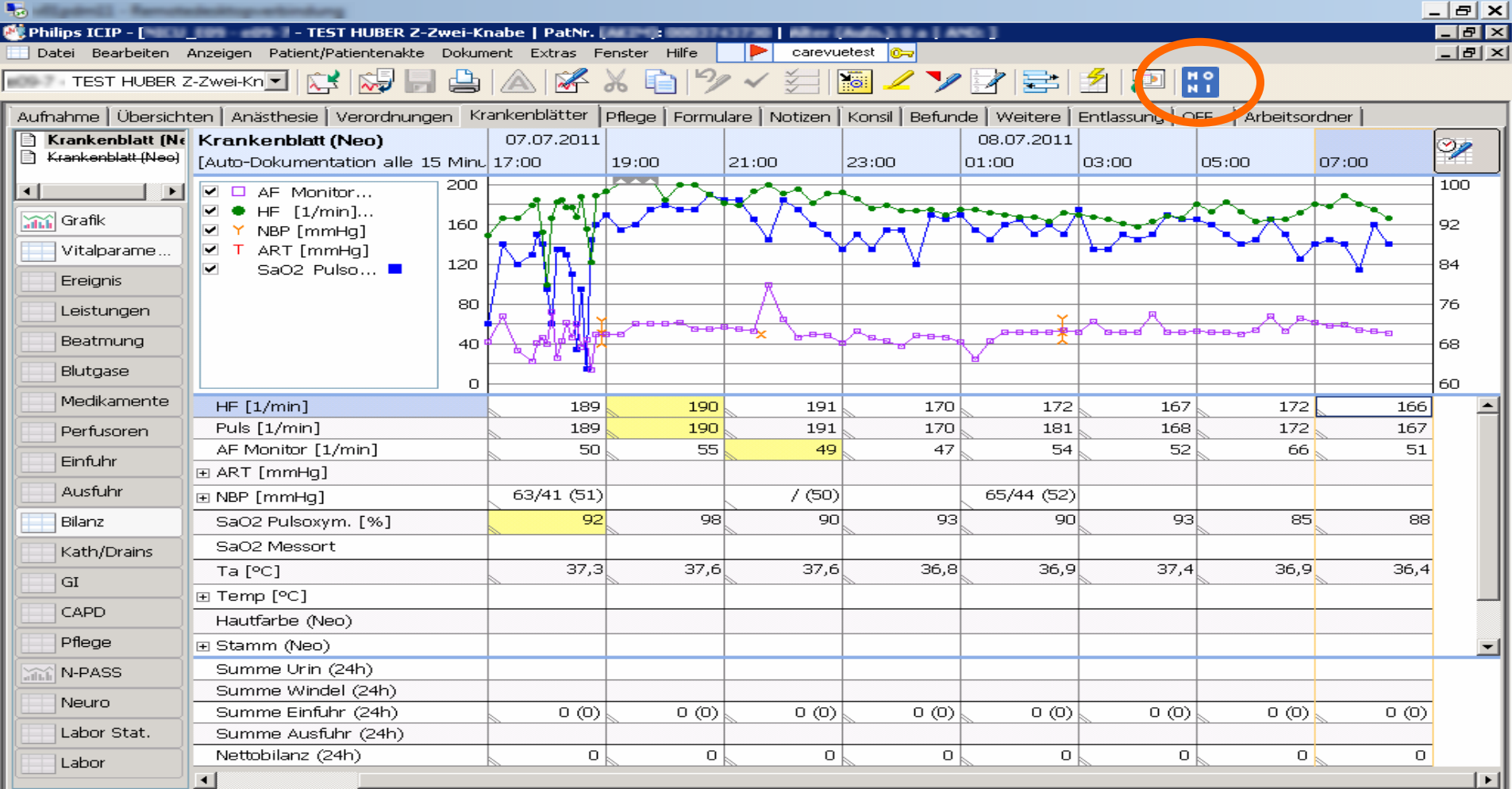
- vital signs
- lab data
- demographics
- ATD info
- ICD codes

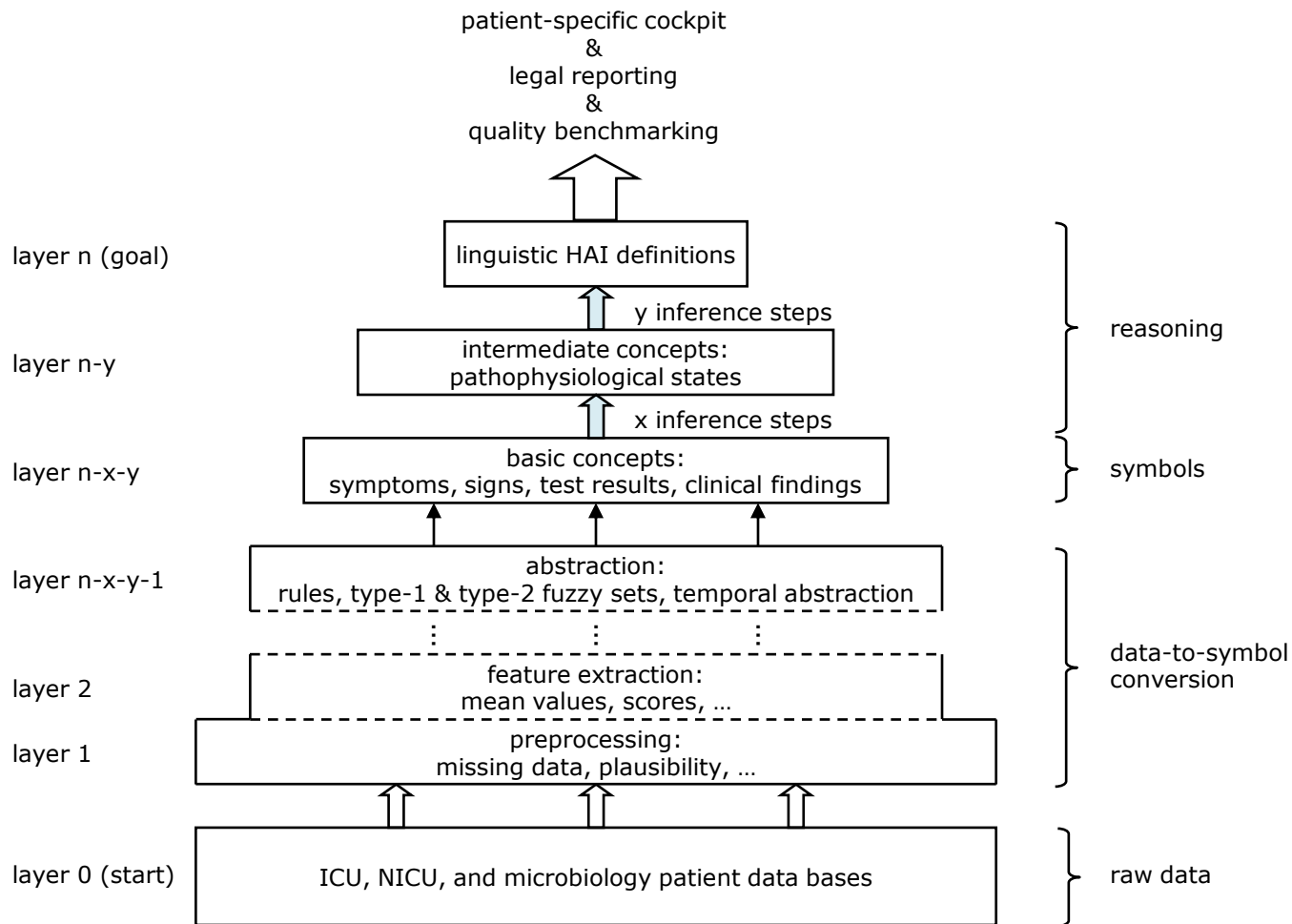
© 2014 Epic Systems Corporation. Used with permission.

Example of e-mail from HFRRS MLM to HF nurse practitioners:

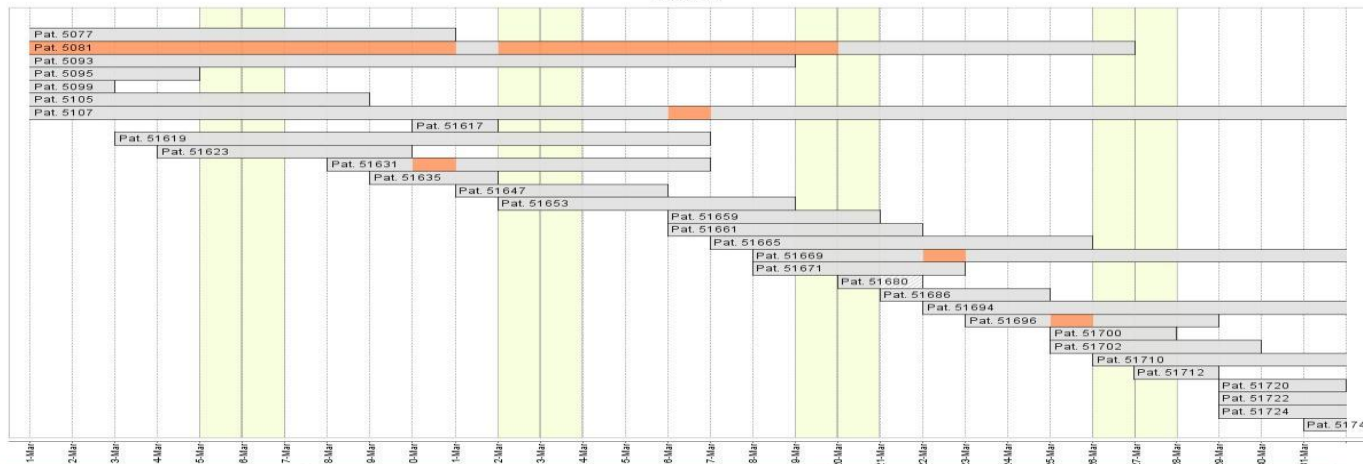
Message: [REDACTED] | [REDACTED] | Heart Failure Readmission Risk Score = 21 - scores > 20 indicate the patient is at risk for readmission. | Service: Hospitalist-HMS1 | Provider: [REDACTED] | MD [REDACTED]

- patient follow-up and authorization of additional inpatient services (e.g., occupational and physical therapy)





from 2013-03-01 to 2013-03-31 show clinic ward 27 hide diagram fixed table width



Moni-ICU cockpit

department / patient

ward 30	
ward 28	
ward 27	
Pat. 5077	
Pat. 5081	
Pat. 5093	
Pat. 5095	
Pat. 5099	
Pat. 5105	
Pat. 5107	
Pat. 51617	
Pat. 51619	
Pat. 51623	
Pat. 51631	
Pat. 51635	
Pat. 51647	
Pat. 51653	
Pat. 51659	
Pat. 51661	
Pat. 51665	
Pat. 51669	
Pat. 51671	
Pat. 51680	

Pat. 5107

▲ 2013-03-17 (ward 27)	
▲ 2013-03-16 (ward 27)	
UTI-B (sympt. urinary tract infection)	100 %
UTI-B-k (cath. assoc. sympt. urinary tract in...	100 %
inflamm. symptoms in UTI	100 %
inflamm. symptoms in sepsis	100 %
other signs of UTI	100 %
fever	80 %
hypotension	80 %
raised CRP	100 %
leukopenia	100 %
shock	100 %
inc. body temperature	40 %
max. body temperature	37.7 °C
proportion of leukocytes	1.55 G/L
CVC	100 %
inflamed puncture site	100 %
urinary catheter	100 %
thermoregulation	100 %
ventilated	100 %
systemic antibiotics	100 %
urinary culture with < 10 ⁵ CFU/ml	100 %
▲ 2013-03-15 (ward 27)	
▲ 2013-03-14 (ward 27)	
▲ 2013-03-13 (ward 27)	
▲ 2013-03-12 (ward 27)	
▲ 2013-03-11 (ward 27)	
▲ 2013-03-10 (ward 27)	
▲ 2013-03-09 (ward 27)	
▲ 2013-03-08 (ward 27)	
▲ 2013-03-07 (ward 27)	
▲ 2013-03-06 (ward 27)	
▲ 2013-03-05 (ward 27)	
▲ 2013-03-04 (ward 27)	
▲ 2013-03-03 (ward 27)	
▲ 2013-03-02 (ward 27)	
▲ 2013-03-01 (ward 27)	
▲ 2013-02-28 (ward 27)	
2013-02-27 (ward 27) no data	

UTI-B (sympt. urinary tract infection)	
UTI-B-k (cath. assoc. sympt. urinary tract in...	100 %
UTI-B-k (cath. assoc. sympt. urinary tract infection)	
AND	
urinary catheter (t-2d - t)	100 %
inflamm. symptoms in UTI	100 %
other signs of UTI	100 %
inflamm. symptoms in UTI	
OR	
fever	100 %
leukopenia	80 %
raised CRP	100 %
fever	
thermoregulation	100 %
leukopenia	
max. percentage of leukocytes	1.55 G/L
inc. CRP	
max. CRP	16.24 mg/...
max. CRP	
CRP	16.24 mg/...
other signs of UTI	
urinary culture with < 10 ⁵ CFU/ml	100 %

stay in hospital
 stay at department
 no data
 10% - 50%
 50% - 90%
 90% - 100%
 100%

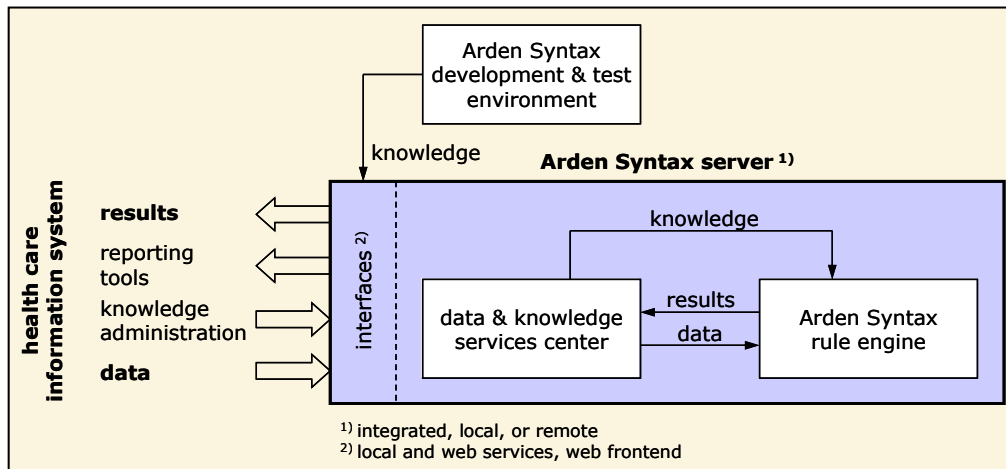
urinary catheter (t-2d - t)	
Harnkatheter 1: Befund - unauffällig; Katheter/Sonde - Harnkatheter1;	
Harnkatheter 1: Versorgung - Druckschutz; Harnkatheter 1: Ch/Material - 14,	
16	
thermoregulation	
Thermoregulation - abdecken	
CRP	
Serum: CRP	
urinary culture with < 10 ⁵ CFU/ml	
2011H004811, 2013-03-16 03:00, Katheterharn (nativ): Pseudomonas	
aeruginosa (10 hoch 4/ml)	

Fuzzy Arden Syntax: Modelling uncertainty in medicine

- **linguistic uncertainty**
 - due to the unsharpness (fuzziness) of boundaries of linguistic concepts; gradual transition from one concept to another
 - modeled by fuzzy sets (e.g., fever, increased glucose level, hypoxemia)
- **propositional uncertainty**
 - due to the incompleteness of medical conclusions; uncertainty in definitional, causal, statistical, and heuristic relationships
 - **here:** modeled by truth values between zero and one (e.g., 0.6, 0.9)

Arden Syntax server and software components

- Arden Syntax integrated development and test environment (IDE) including
 - Medical logic module (MLM) editor and authoring tool
 - Arden Syntax compiler (syntax versions 2.1, 2.5, 2.6, 2.7, 2.8, 2.9, and 2.10)
 - Arden Syntax engine
 - MLM test environment
 - MLM export component
- command-line Arden Syntax compiler



- web-services-based Arden Syntax server including
 - Arden Syntax engine
 - MLM manager
 - XML-protocol-based interfaces, e.g., SOAP, REST, and HL7
 - a project-specific data and knowledge services center may be hosted
- Java libraries
 - Arden Syntax compiler
 - Arden Syntax engine

Automated interpretation of hepatitis serology test results

Hepaxpert/Interpretation
Knowledge-based interpretation of hepatitis A, B, and C serology

Input of test results

Hepatitis A serology

anti-HAV ☒ positive ☐ negative ☐ borderline ☐ not tested

IgM anti-HAV ☐ positive ☒ negative ☐ borderline ☐ not tested

HAV-RNA ☐ positive ☒ negative ☐ borderline ☐ not tested

Hepatitis B serology

HBsAg ☐ positive ☒ negative ☐ borderline ☐ not tested

anti-HBs ☐ positive ☒ negative ☐ borderline ☐ not tested

anti-HBc ☒ positive ☐ negative ☐ borderline ☐ not tested

IgM anti-HBc ☒ positive ☐ negative ☐ borderline ☐ not tested

HBsAg ☐ positive ☒ negative ☐ borderline ☐ not tested

anti-HBe ☐ positive ☒ negative ☐ borderline ☐ not tested

anti-HBs titre U/I

Hepatitis C serology

anti-HCV ☒ positive ☐ negative ☐ borderline ☐ not tested

HCV-RNA ☐ positive ☒ negative ☐ borderline ☒ not tested

Interpretation

Hepatitis A serology

anti-HAV **positive** IgM anti-HAV **negative** HAV-RNA **negative**

Positive results for total anti-HAV antibodies in combination with negative results for IgM anti-HAV antibodies indicate immunity to the hepatitis virus A and exclude the possibility of a recent hepatitis A. This immunity may either have been acquired naturally through an earlier infection or it may have been induced by active vaccination or passively acquired immunization.

Hepatitis B serology

HBsAg **negative** anti-HBs **negative** anti-HBc **positive** IgM anti-HBc **negative** HBsAg **negative** anti-HBe **negative** anti-HBs titre **not tested**

This constellation of findings (positive IgM anti-HBc antibodies with negative HBs- and HBe-antigen and negative anti-HBs and anti-HBe antibodies) occurs in the course of acute hepatitis B and is characteristic of the seroconversion both of HBs-antigen to anti-HBs and of HBe-antigen to anti-HBe antibodies. This stage may be regarded as a favorable prognostic sign with a view to a non-chronic course of the disease. Blood and secretions (saliva, sperm, breast milk) of the patient are to be considered infectious.

Hepatitis C serology

anti-HCV **positive** HCV-RNA **not tested**

There is a recent or chronic persisting or an earlier hepatitis C virus infection. An additional test for HCV-RNA adds further information. Blood of such patients may be considered as infectious with regard to hepatitis C.

Important Notice

The attending physician alone is responsible for the patient's diagnosis and therapy. Therefore, contact a doctor at all times. Only the doctor will be able to align the Hepaxpert interpretation with the full clinical picture of the patient.

Hepatitis B Serology

Parameters

HBsAg **negative**

anti-HBs **negative**

anti-HBc **positive**

IgM anti-HBc **positive**

HBsAg **negative**

anti-HBe **negative**

anti-HBs titre **not tested**

Results

This constellation of findings (positive IgM anti-HBc antibodies with negative HBs- and HBe-antigen and negative anti-HBs and anti-HBe antibodies) occurs in the course of acute hepatitis B and is characteristic of the seroconversion both of HBs-antigen to anti-HBs and of HBe-antigen to anti-HBe antibodies. This stage may be regarded as a favorable prognostic sign with a view to a non-chronic course of the disease. Blood and secretions (saliva, sperm, breast milk) of the patient are to be considered infectious.

- includes frequent, rare, as well as inconsistent combinations
- complete coverage of the problem domains
- e.g., hepatitis B serology: about 150 rules in 3 layers for more than 61,000 possible combinations

To summarize

- Arden Syntax software: versatile, scalable, data- and knowledge-processing software for CDS and quality measures
 - High integratability through web services and database connectors
 - Cockpit monitoring of and dashboard analytics for adverse events
 - Reporting and quality benchmarking of adverse events
 - **Users:** patient-care institutions, healthcare and research institutions, health IT companies, and consumers
-