Artificial-intelligence-augmented clinical medicine

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Artificial intelligence (1)

- *Definition 1*: AI is a field of science and engineering concerned with the computational understanding of what is commonly called intelligent behavior, and with the creation of artifacts that exhibit such behavior.

from: Shapiro, S.C. (1992) Artificial Intelligence. In Shapiro, S.C. (ed.) *Encyclopedia of Artificial Intelligence*, 2nd ed., vol. 1, Wiley, New York, 54–57.

- *Definition 2*: AI is the science of artificial simulation of human thought processes with computers.

from: Feigenbaum, E.A. & Feldman, J. (eds.) (1995) *Computers & Thought*. AAAI Press, Menlo Park, back cover.

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Artificial intelligence—applicable to clinical medicine

- It is the decomposition of an entire clinical thought process and its separate artificial simulation—also of simple instances of "clinical thought"—that make the task of AI in clinical medicine manageable.

- A functionally-driven science of AI that extends clinicians through computer systems step by step can immediately be established.

artificial-intelligence-augmented clinical medicine

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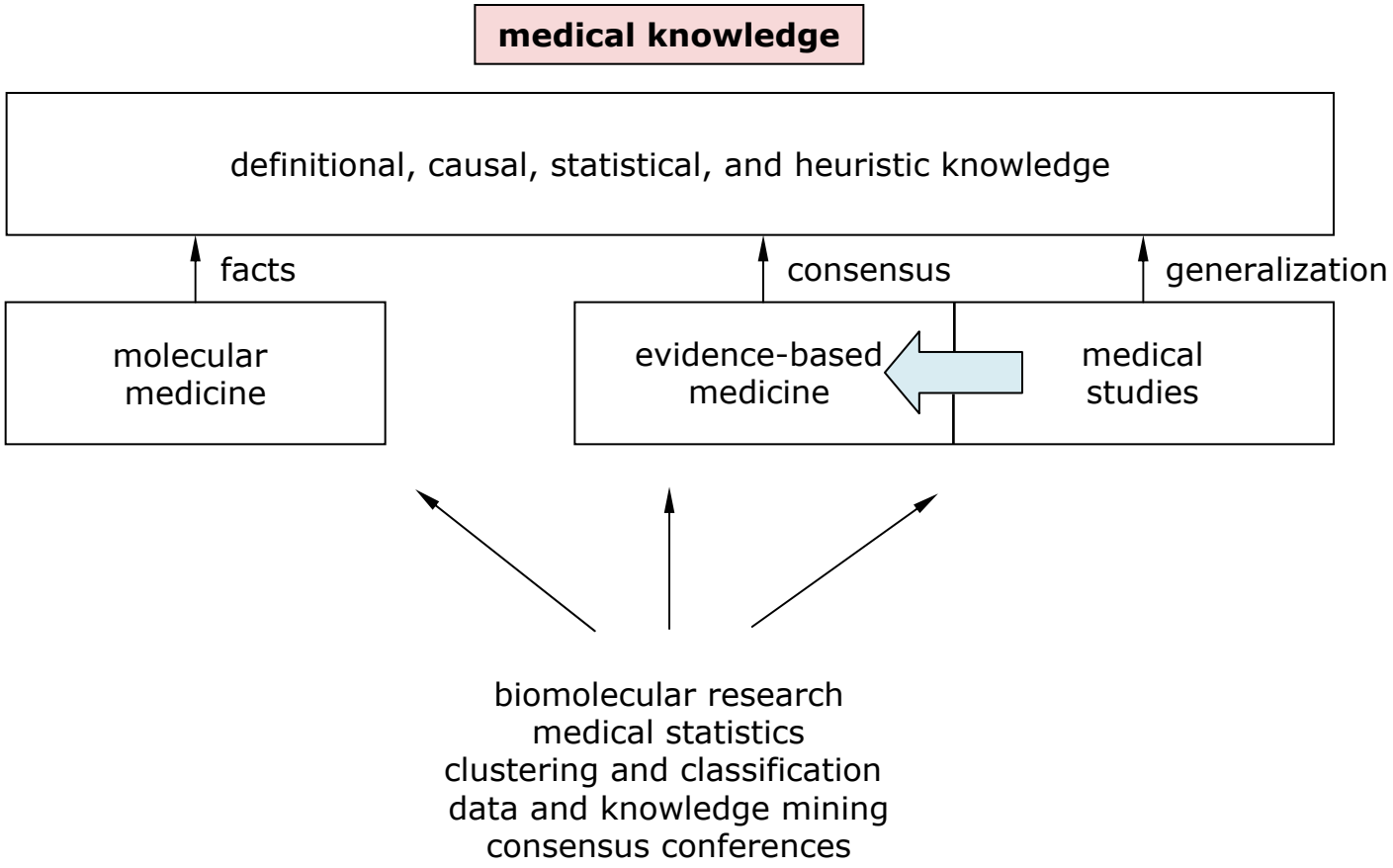
Computational intelligence in medical research



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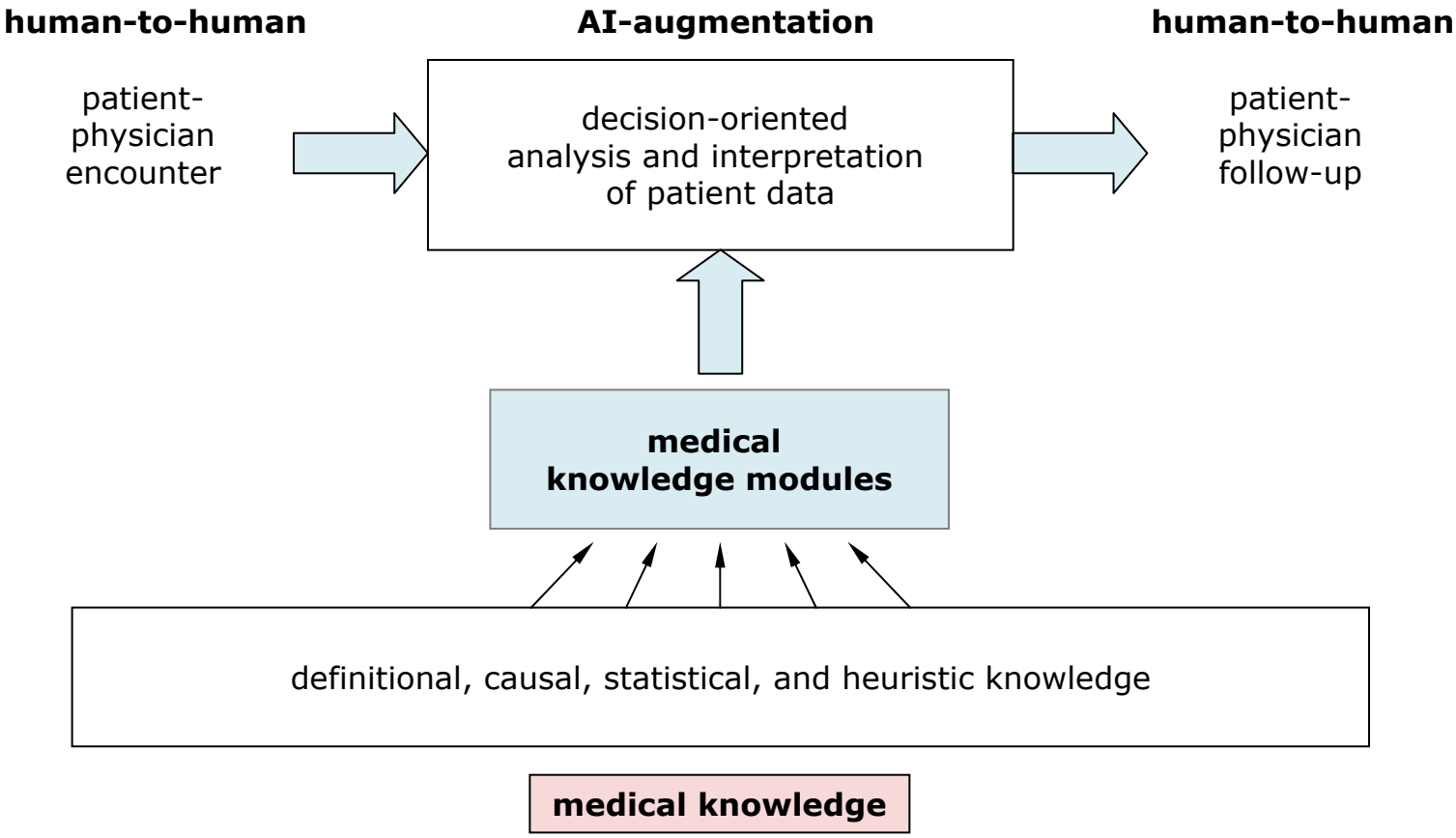
Computational intelligence in patient care



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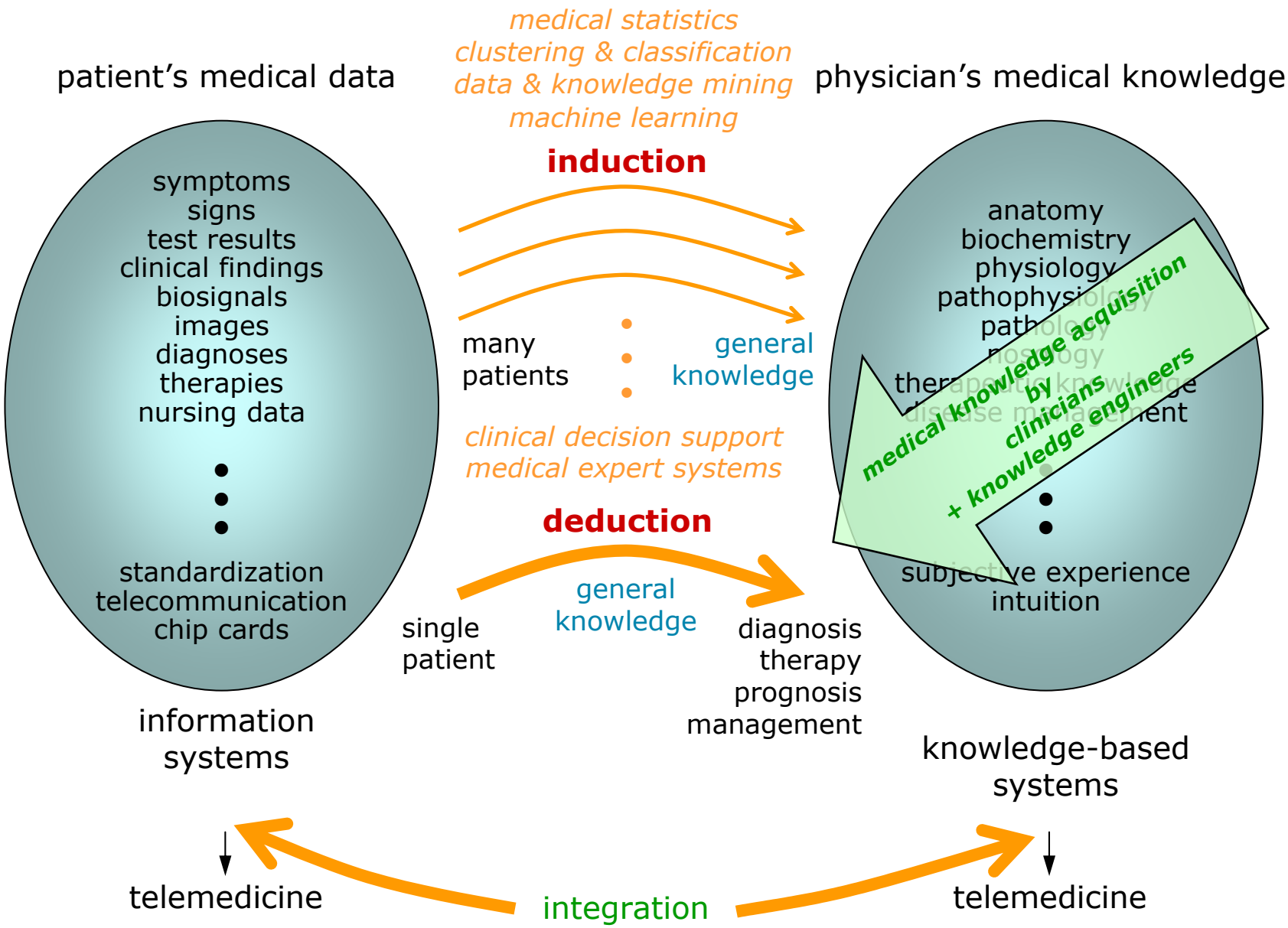
Computers in clinical medicine

Steps of natural progression

- step 1: patient administration
  - ADT and billing
- step 2: medical data
  - electronic health record
- step 3: medical data retrieval and analysis
  - research databases, studies, quality management
- step 4: knowledge-based systems for clinical decision support
  - safety net, patient-centered quality assurance
    … for the individual patient
    … and the physician
    … and the medical institution

Medical information and knowledge-based systems



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Clinical decision support

diagnosis • clinical alerts, reminders, calculations • data interpretation, (tele)monitoring • single or differential diagnosis – further or redundant diagnostic investigations – all pathological signs accounted for • consensus-criteria-based diagnosis – definitions – classification criteria	**therapy** • drug alerts, reminders, calculations – indication, contraindications, redundant medications, substitutions – drug allergies, interactions, dosage calculations, consequent orders • management of antibiotics therapy • (open-loop) control systems
prognosis • illness severity scores, prediction rules • trend detection and visualization	**patient management** • administrative reminders • computerized clinical guidelines, protocols • community- and hospital-acquired infections, cross infections • high-level patient and hospital analytics

Hepaxpert/Interpretation

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

Input of test results

Interpretation

FAQs

Scientific development

Scientific publications

Feedback

English version

Deutsche Version

Interpretation

Hepatitis A serology

anti-HAV	IgM anti-HAV	HAV-RNA
positive	not tested	not tested

Antibodies to the hepatitis virus A may occur in three different situations: (a) in the case of a recent hepatitis A virus infection (acute icteric or anicteric hepatitis A, subclinical disease, or stage of convalescence from hepatitis A), (b) in the case of immunity after an earlier hepatitis A virus infection, or (c) after active vaccination or in the case of passively acquired immunity through injection of gamma globulin.

Hepatitis B serology

HBsAg	anti-HBs	anti-HBc	IgM anti-HBc
negative	not tested	not tested	negative
HBeAg	**anti-HBe**	**anti-HBs titre**	
not tested	not tested	2000 U/l	

This constellation of findings (positive anti-HBs antibodies, with negative IgM anti-HBc antibodies) indicates the presence of immunity to the hepatitis virus B. This immunity may either have been acquired naturally upon restitution following a hepatitis B virus infection or it may have been induced by active or passive immunization.

Vaccination Recommendation: If an indication for a hepatitis B vaccination exists, the primary course of immunization has been completed, the last partial vaccination was given at least 1 month previously, and the vaccinated person's immunity is unimpaired, then a hepatitis B vaccination (or a follow-up anti-HBs titre check) within 5 years, based on the titre examination date, is to be recommended at the measured anti-HBs titre value of 2000 U/l.

Hepatitis C serology

anti-HCV	HCV-RNA
positive	negative

The findings obtained give an indication of a formerly passed HCV infection or the remission of a present HCV infection. If on account of the clinical picture hepatitis C is suspected, follow-up tests are recommendable. 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.

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One of the rules to interpret clinically relevant findings (rule premises form equivalent classes)

RULE 103:

IF one of the following 100 combinations

HBsAg	anti-HBs	anti-HBc	IgM anti-HBc	HBeAg	anti-HBe
+ •	+	− ±	− ± •	+	− ± •
+ •	+	+ •	+ − ± •	+	+ − ± •

THEN

The simultaneous occurrence of HBe-antigen and anti-HBs antibodies is a rare event in the natural course of a hepatitis B virus infection. This constellation of findings may be attributed to one of the following causes: (a) circulating HBsAg-anti-HBs immune complexes, (b) hepatitis B virus infection coinciding with a hepatitis B vaccination or injection of HB-hyperimmune globulin, or (c) reinfection with a hepatitis virus B with a different HBsAg subtype. Blood and secretions (saliva, sperm, breast milk) of such patients are to be regarded as infectious.

	Befund 02.05.2001 (09:46)	Vor-Befund	Referenzbereich und Einheit	
PROTEINDIAGNOSTIK				
CRP	61.5 ***		0.8-5.0	mg/l
HORMONE				
	Schilddrüsendiagnostik			
TSH	3.00		0.2-3.5	mU/l
INFEKTIONSSEROLOGIE				
HIV-Antikörper	Negativ			Negativ
HEPATITIS-SEROLOGIE				
Anti-HAV-IgM	Negativ			Negativ
Anti-HAV	**Positiv** *			Negativ
HBsAG	Negativ			
Anti-HBs	Negativ			
Anti-HBs (quant.)	1.42			U/l
Anti-HBc	Negativ			
Anti-HCV	Negativ			Negativ

Medizin. Kommentar/Interpretation:

HEPATITIS-SEROLOGIE:

Positive Gesamtkörper (Anti-HAV) bei negativen IgM-anti-HAV Antikörpern beweisen Immunität gegen das Hepatitis-A-Virus und schließen eine rezente Hepatitis A aus. Diese Immunität kann entweder durch eine frühere Infektion natürlich erworben oder aber durch aktive Impfung oder passive Immunisierung induziert sein.

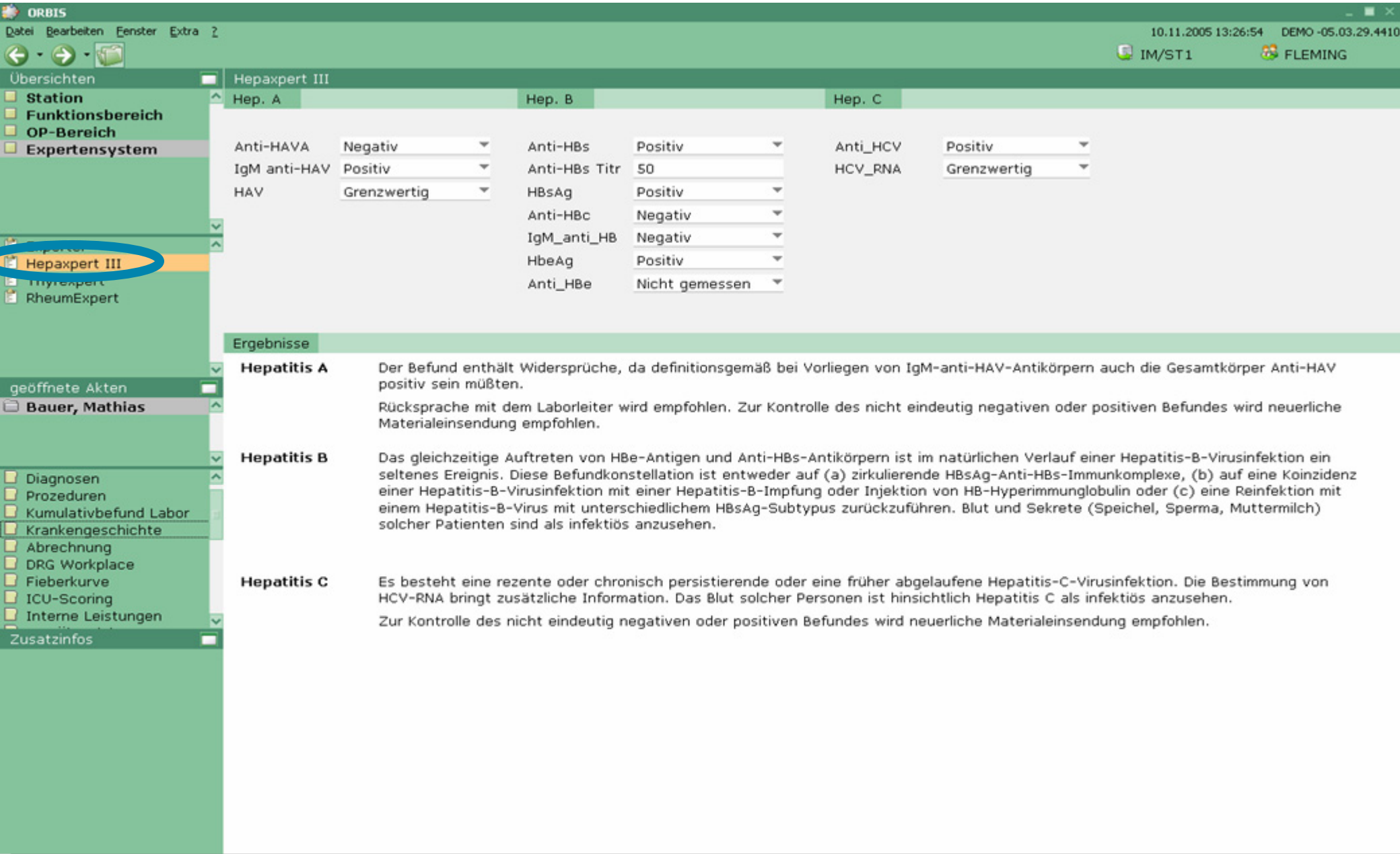
Anti-HBs Titer: 1 Units/Liter

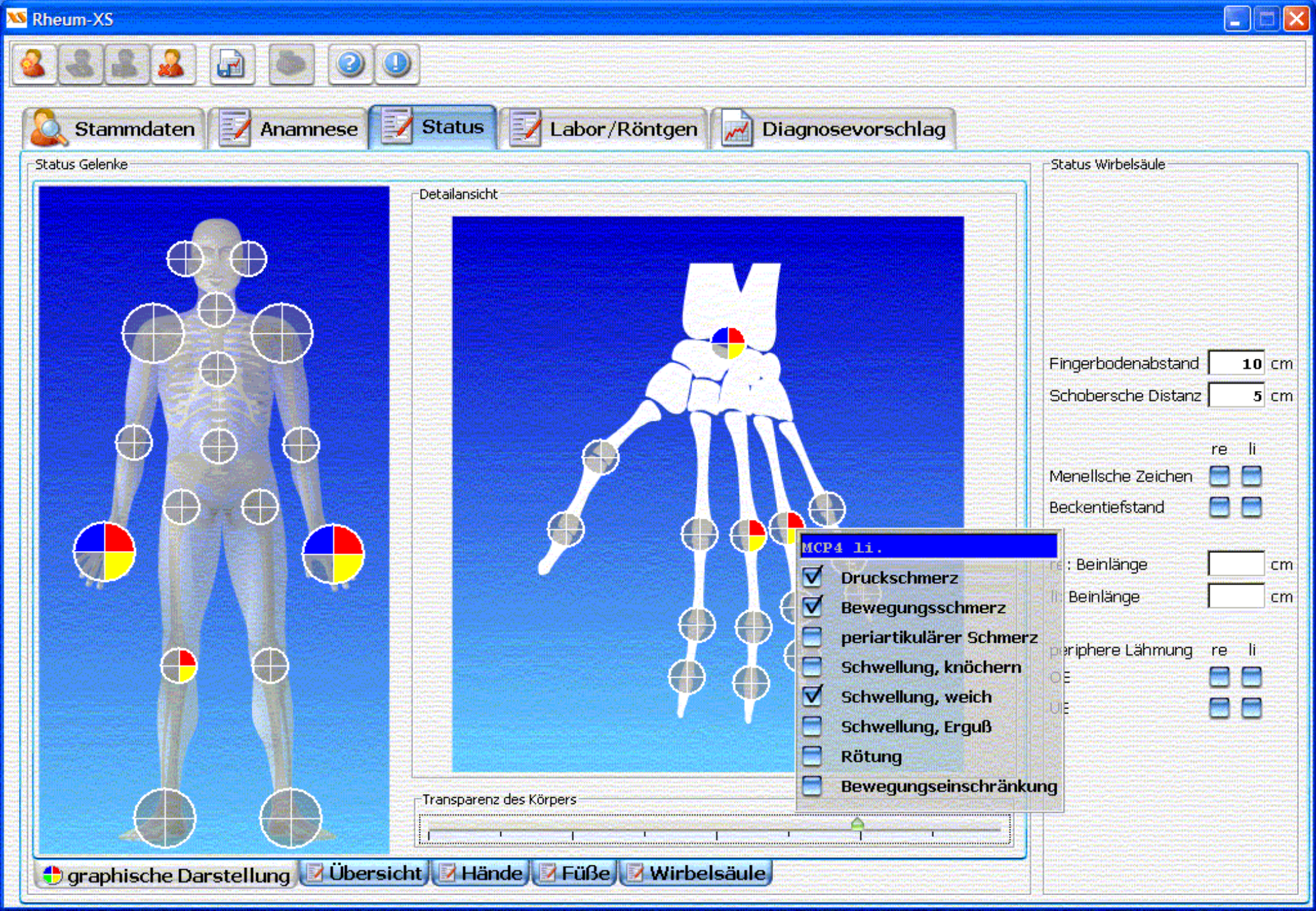
Eine bestehende oder frühere Hepatitis-B-Virusinfektion kann (mit Ausnahme des Inkubationsstadiums) ausgeschlossen werden. Es besteht keine Immunität gegen das Hepatitis-B-Virus. Das Blut kann hinsichtlich Hepatitis B als nicht infektiös angesehen werden. Impfempfehlung: Die Indikation zur Hepatitis-B-Impfung vorausgesetzt, soll in diesem Fall bei einem Ungeimpften die Grundimmunisierung (entsprechend dem Schema des jeweiligen Impfstoffes) durchgeführt und - zur Abschätzung der Immunantwort - 1-2 Monate nach der letzten Teilimpfung der Anti-HBs Titer bestimmt werden. Bei einem Geimpften mit abgeschlossener Grundimmunisierung soll unverzüglich eine Booster Injektion gegeben und - falls der Verdacht eines ælow respondersÆ besteht - eine Titerkontrolle 2 Monate nach dem Booster erhoben werden.

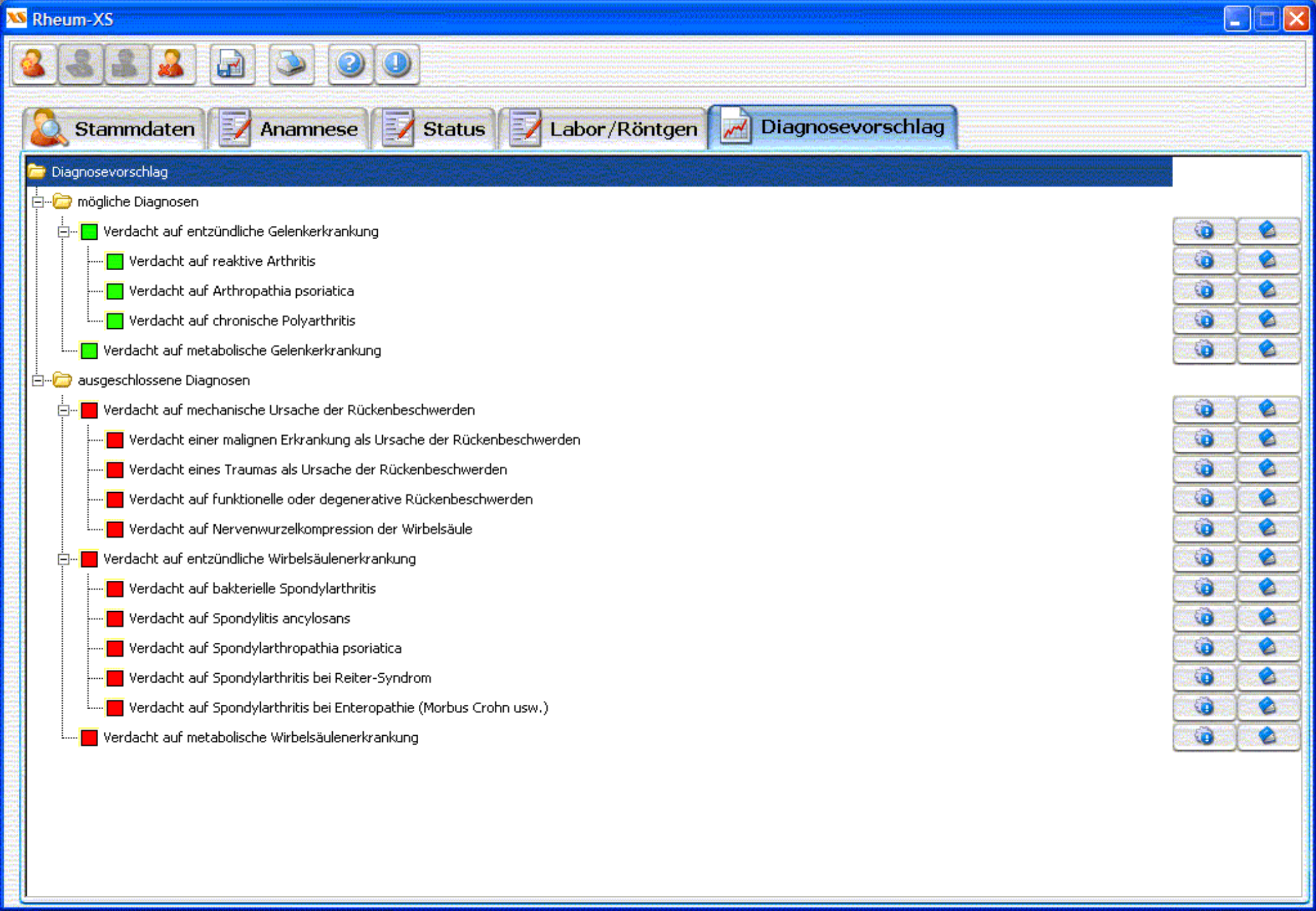
test results

interpretation

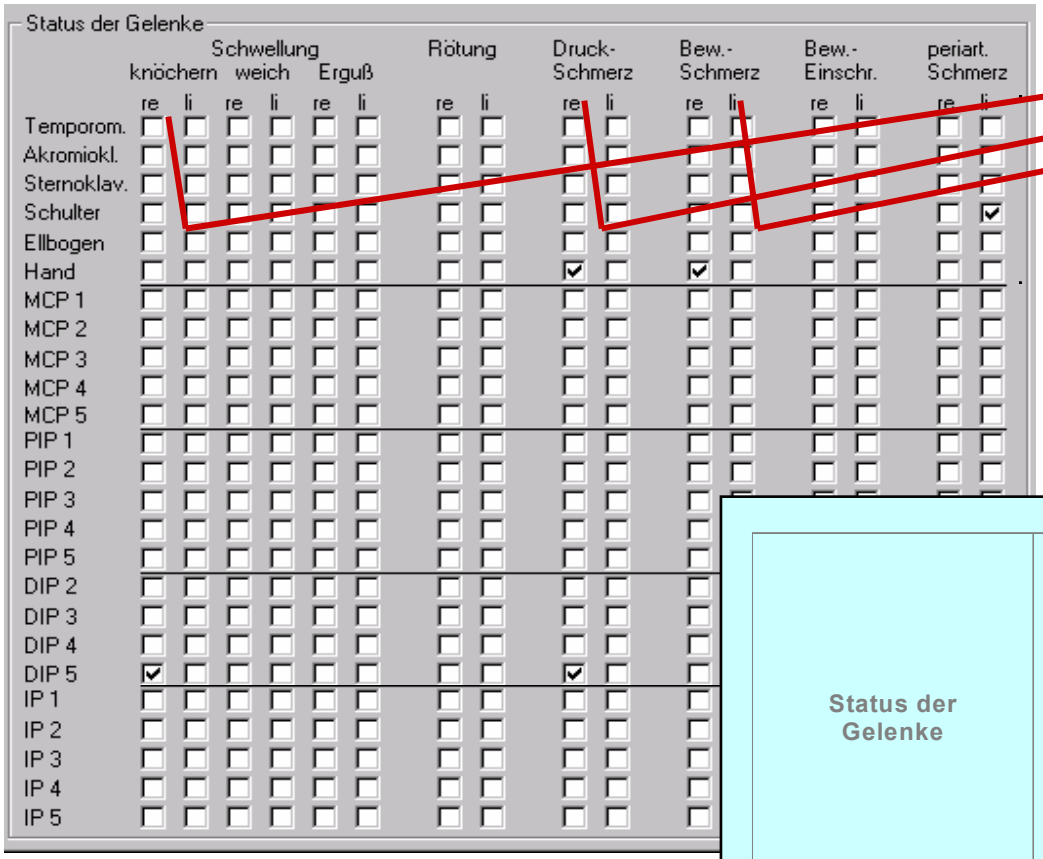
ORBIS Experter: Hepatitis serology diagnostics




Rheum-XS
Stammdaten
Anamnese
Status
Labor/Röntgen
Diagnosevorschlag
Status Gelenke
Detailansicht
MCP4 li.
Druckschmerz
Bewegungsschmerz
periartikulärer Schmerz
Schwellung, knöchern
Schwellung, weich
Schwellung, Erguß
Rötung
Bewegungseinschränkung
Transparenz des Körpers
Status Wirbelsäule
Fingerbodenabstand 10 cm
Schobersche Distanz 5 cm
re li
Menellsche Zeichen
Beckentiefstand
: Beinlänge cm
Beinlänge cm
re li
graphische Darstellung
Übersicht
Hände
Füße
Wirbelsäule


Rheum-XS
Stammdaten
Anamnese
Status
Labor/Röntgen
Diagnosevorschlag
Diagnosevorschlag
mögliche Diagnosen
Verdacht auf entzündliche Gelenkerkrankung
Verdacht auf reaktive Arthritis
Verdacht auf Arthropathia psoriatica
Verdacht auf chronische Polyarthritis
Verdacht auf metabolische Gelenkerkrankung
ausgeschlossene Diagnosen
Verdacht auf mechanische Ursache der Rückenbeschwerden
Verdacht einer malignen Erkrankung als Ursache der Rückenbeschwerden
Verdacht eines Traumas als Ursache der Rückenbeschwerden
Verdacht auf funktionelle oder degenerative Rückenbeschwerden
Verdacht auf Nervenwurzelkompression der Wirbelsäule
Verdacht auf entzündliche Wirbelsäulenerkrankung
Verdacht auf bakterielle Spondylarthritis
Verdacht auf Spondylitis ancylosans
Verdacht auf Spondylarthropathia psoriatica
Verdacht auf Spondylarthritis bei Reiter-Syndrom
Verdacht auf Spondylarthritis bei Enteropathie (Morbus Crohn usw.)
Verdacht auf metabolische Wirbelsäulenerkrankung

data level



data-to-symbol conversion

degenerative affection of one or more distal joints

at least 1 out of 18:
DIP r or DIP l or IP r or IP l and
per joint: (tenderness or pain on motion) and osseous swelling

symbol level

Status der Gelenke		Verdacht auf mechanische Ursache der Rückenbeschwerden	Verdacht einer malignen Erkrankung als Ursache der Rückenbeschwerden	Verdacht eines Traumas als Ursache der Rückenbeschwerden	Verdacht auf funktionelle oder degenerative Rückenbeschwerden	Verdacht auf Nervenwurzelkompression [der Wirbelsäule]	Verdacht auf entzündliche Wirbelsäulenerkrankung	Verdacht auf bakterielle Spondylarthritis	Verdacht auf Spondylitis ancylosans	Verdacht auf Spondylarthropathia psoriatica	Verdacht auf Spondylarthritis bei Reiter-Syndrom	Verdacht auf Spondylarthritis bei Enteropathie (Morbus Crohn usw.)	Verdacht auf metabolische Wirbelsäulenerkrankung	Verdacht auf entzündliche Gelenkerkrankung	Verdacht auf chronische Polyarthritis	Verdacht auf Arthropathia psoriatica	Verdacht auf reaktive Arthritis	Verdacht auf bakterielle Arthritis	Verdacht auf metabolische Gelenkerkrankung	Verdacht auf degenerative Gelenkerkrankung	Verdacht auf weichteil-rheumatische Erkrankung
Gelenke o.B.	21													-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0
knöcherne Schwellung eines oder mehrerer Gelenke	22													0,25						0,4	
weiche Schwellung eines oder mehrerer Gelenke	23													0,6					0,4		
Erguß eines oder mehrerer Gelenke	24													0,4					0,4	0,25	-0,9
Rötung eines oder mehrerer Gelenke	25													0,25	-0,15	0,25	0,25	0,4	0,4	0,15	
monoartikulärer Druck- od. Bewegungsschmerz	26													0,4	0,25	0,25	0,4	0,4	0,4	0,4	0,35
oligoartikulärer Druck- od. Bewegungsschmerz	27													0,4					0,25	0,25	0,25
polyartikulärer Druck- od. Bewegungsschmerz	[illegible]													0,4					0,15	0,15	0,25
Bewegungseinschränkung eines oder mehrerer Gelenke	29													0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,25
periartikulärer Schmerz eines oder mehrerer Gelenke	30													0,15						0,15	0,4
entzündlicher Befall eines oder mehrerer distaler Gelenke	31													0,4	0,15	0,4	0,4	0,25			-0,8
degenerativer Befall eines od. mehrerer distaler Gelenke	32																			0,4	
Befall im Strahl	33													0,4		0,4					-0,8
entzündlicher Befall eines oder mehrerer mittlerer oder großer Gelenke	34													0,4	0,4	0,4	0,4	0,4	0,25		-0,8
entzündlicher oligoartikulärer Befall mittlerer oder großer Gelenke	35													0,4	0,15	0,3	0,4				

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Uncertainty in medicine

- imprecision (=fuzziness) of medical concepts
  - due to the unsharpness of boundaries of linguistic concepts; gradual transition from one concept to another
  - modeled by fuzzy sets
- uncertainty of medical conclusions
  - due to the uncertainty of the occurrence and co-occurrence of imprecise medical concepts
  - modeled by SigmaCounts (unconditioned and conditioned frequencies of fuzzy sets)
- incompleteness of medical data and medical theory
  - due to only partially known data and partially known explanations for medical phenomena
  - modeled by fuzzy intervals

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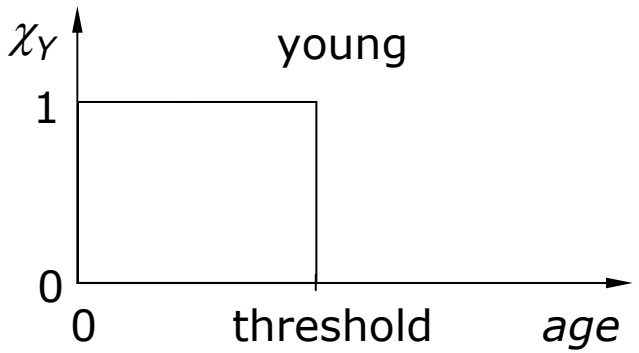
Crisp sets vs. fuzzy sets



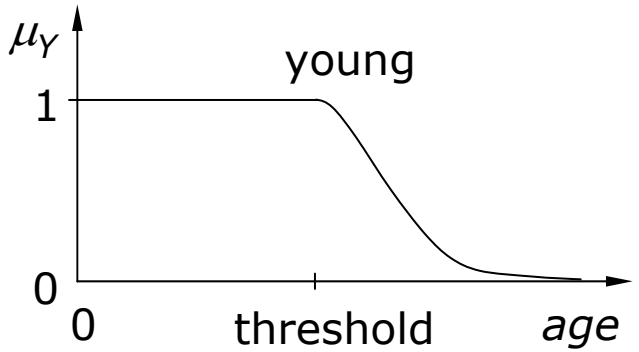
yes/no decision

$U = [0, 120]$

$Y \subseteq U$ with $Y = \{(\chi_Y(x)/\ x) \mid x \in U\}$

$\chi_Y: U \rightarrow \{0, 1\}$

$$\chi_Y(x) = \begin{cases} 0 & x > \text{threshold} \\ 1 & x \leq \text{threshold} \end{cases} \qquad \forall\ x \in U$$



gradual transition

$U = [0, 120]$

$Y \subseteq U$ with $Y = \{(\mu_Y(x)/\ x) \mid x \in U\}$

$\mu_Y: U \rightarrow [0, 1]$

$$\mu_Y(x) = \begin{cases} \dfrac{1}{1 + (0.04\ x)^2} & x > \text{threshold} \\ 1 & x \leq \text{threshold} \end{cases} \qquad \forall\ x \in U$$

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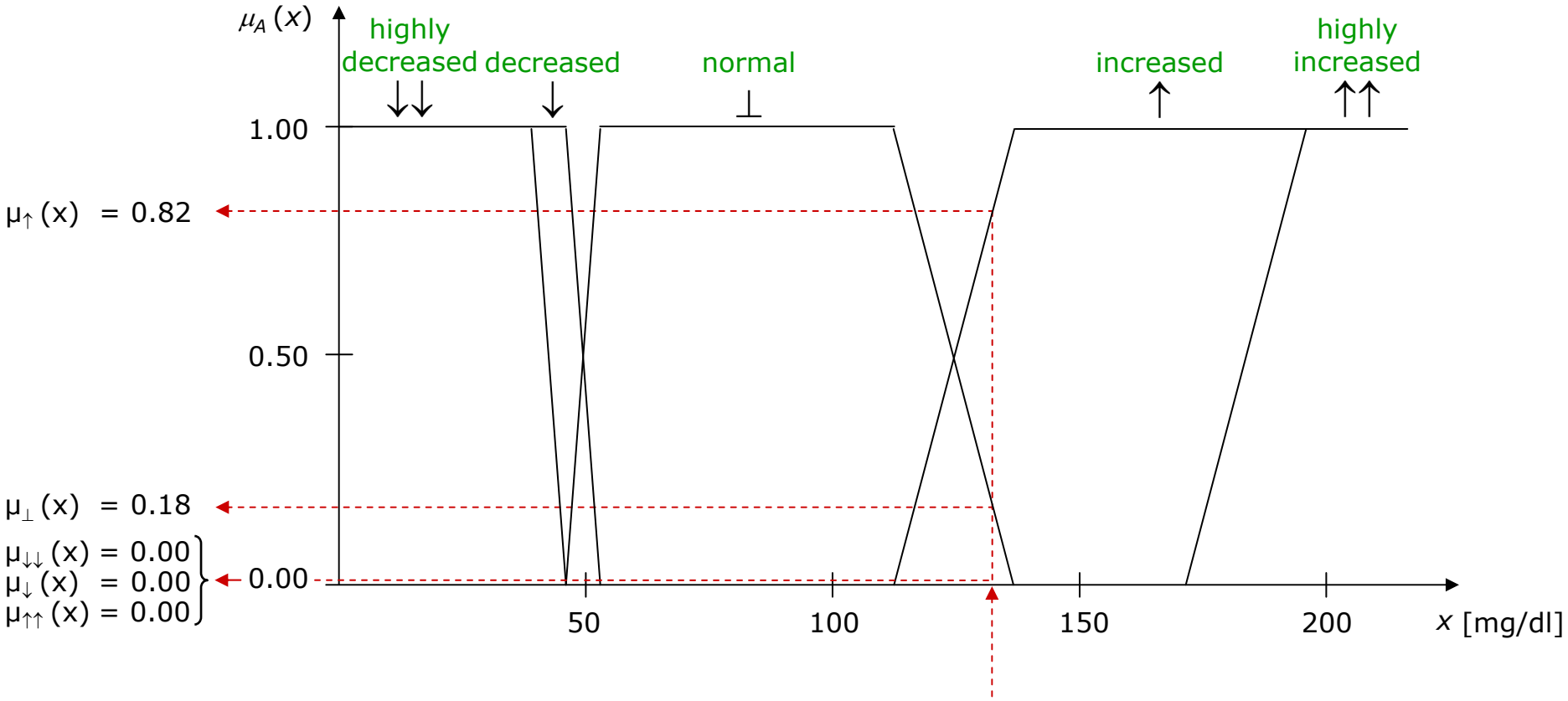
Degree of compatibility [= degree of membership]



glucose level in serum of 130 mg/dl

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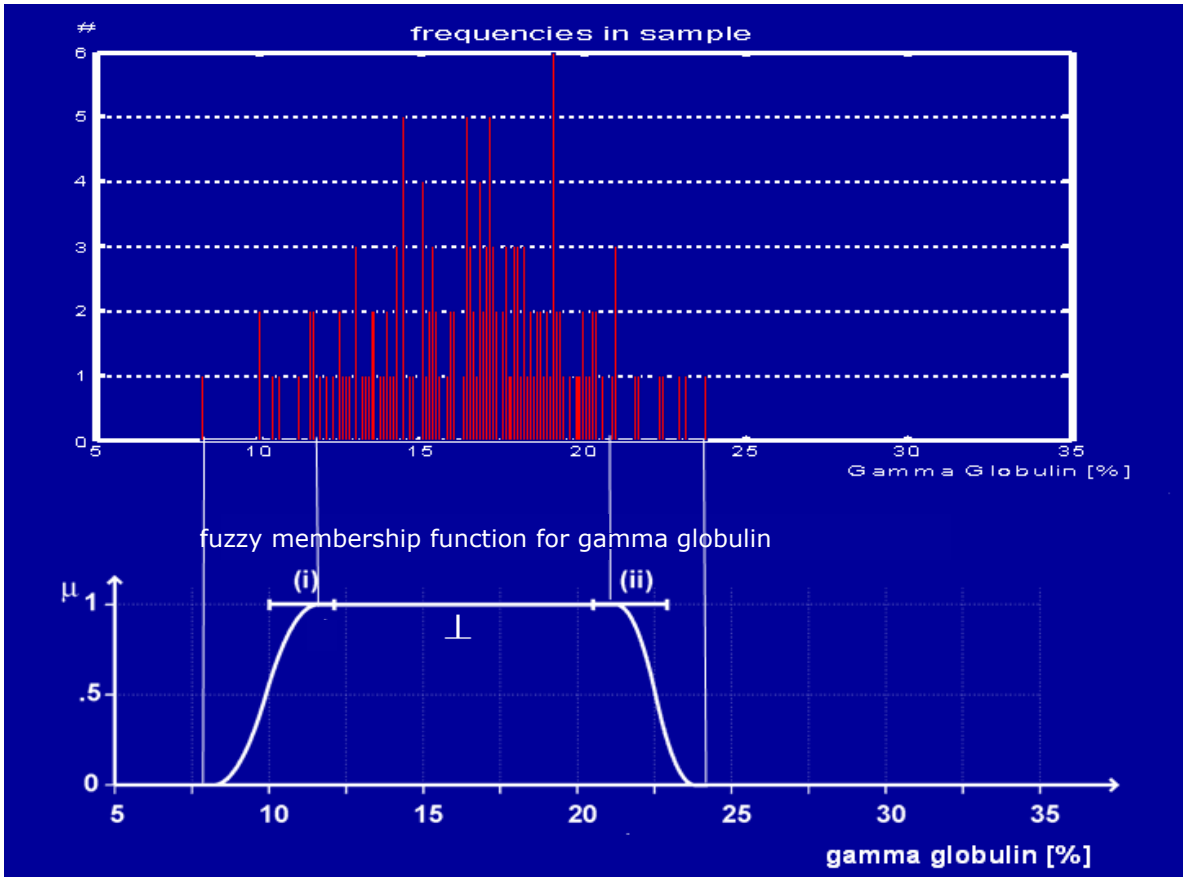
Calculation of fuzzy sets from sample data



***Healthy persons*:**

n = 151

min = 8.2

max = 23.8

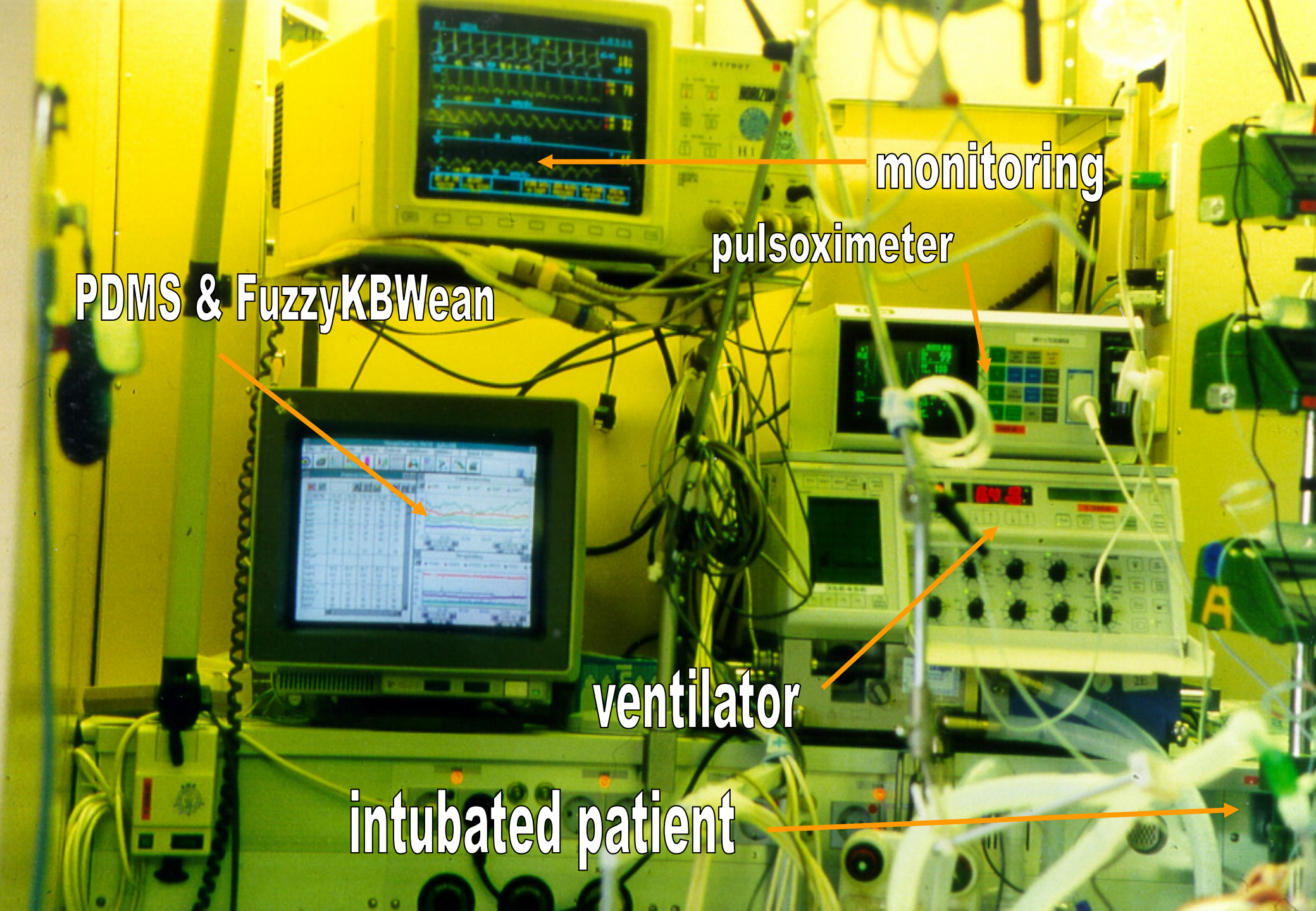
$\varphi_{0,05}$ = 11.6

$\varphi_{0,95}$ = 21.24

$\mu_{\perp}$ = π (*x*; 8.2; 9.9; 11.6; 21.24; 22.52; 23.8)

(i) 90% confidence interval: [10; 12.1]

(ii) 90% confidence interval: [20.5; 22.9]


monitoring
pulsoximeter
PDMS & FuzzyKBWean
ventilator
intubated patient

Knowledge-Based Weaning KBWean - [Patient Bed: V:\Rules\050299_fuzzy.kbe]

Files Configuration Window Help

Start

DataSets: 0 100

HR	SpO2	EtCO2	Rsp_m	Vrate	I_E	TVex	pCO2a	pO2a	pHa	RMV	RSPcap	FiO2	PEEP	PIP	Delta	EtCO2corr
83.75	98.00	29.26	14.25	15.00	2.00	0.538				7.98	15.00	34.00	3.00	16.00	1.02	30.28

Time & Date

22:53 1999.01.22

Changes

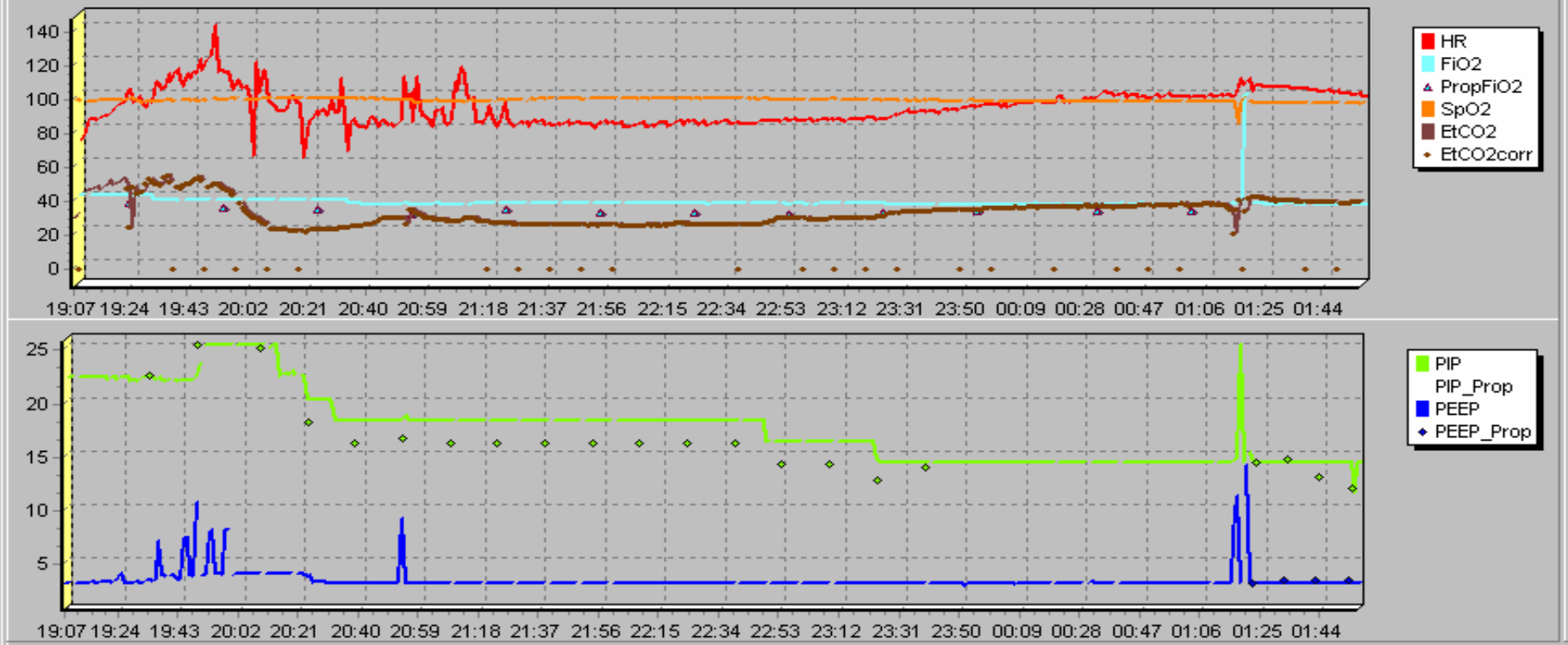
proposed:	29	*	14,11			Confirm
effective:						

Proposals:	
Ventilation_3	Hyperventilation : PIP -2
Oxygenierung_1	Oxygenierung normal : FiO2 -5

Spec. Data-Set

19__.__.__ __:__ Data Set

Comment Empty Table



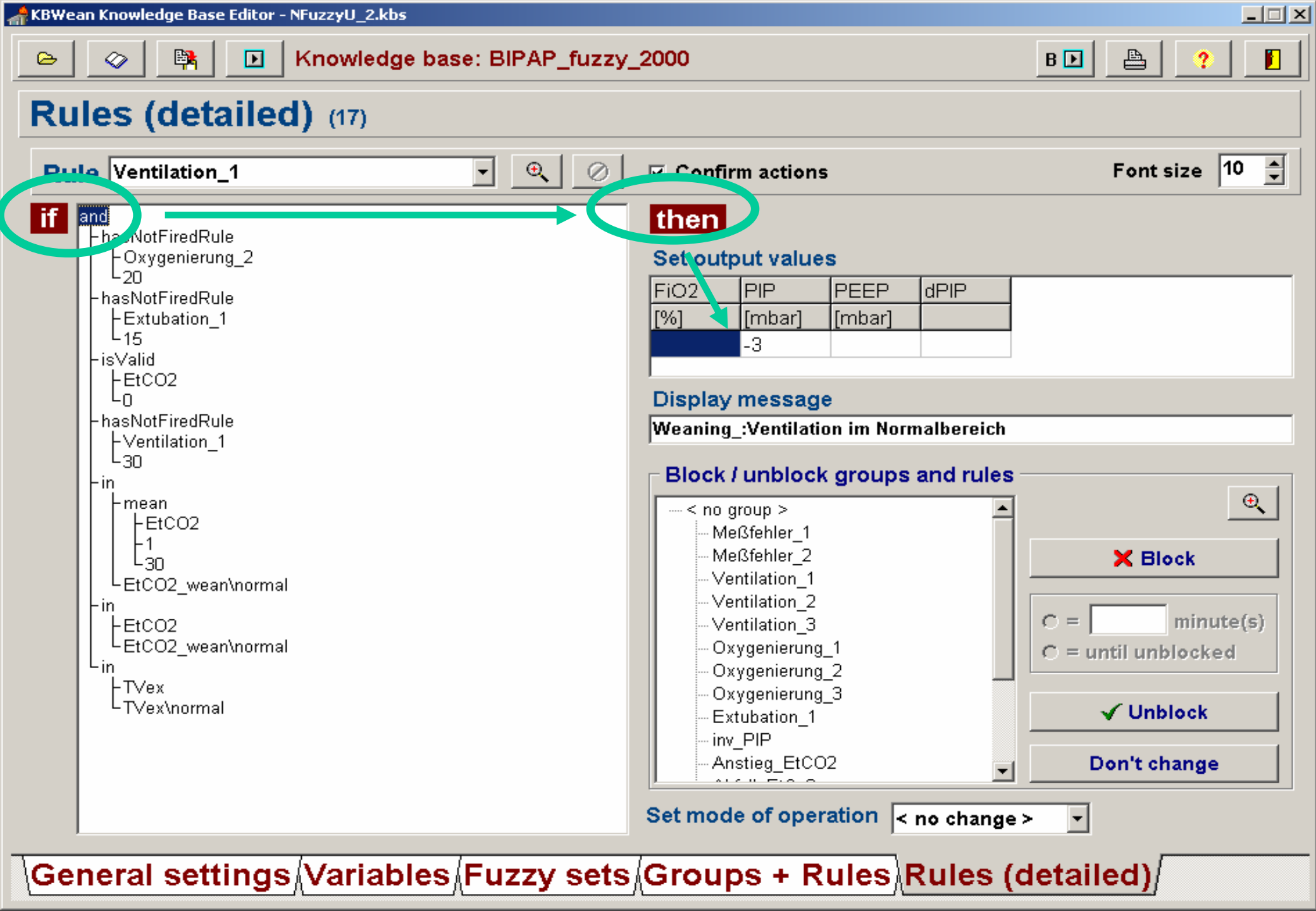
HR FiO2 PropFiO2 SpO2 EtCO2

410

PIP PIP_Prop PEEP PEEP_Prop VRate

3D

5:36:25


KBWean Knowledge Base Editor - NFuzzyU_2.kbs
Knowledge base: BIPAP_fuzzy_2000
Rules (detailed) (17)
Rule
Ventilation_1
Confirm actions
Font size
10
if
and
hasNotFiredRule
Oxygenierung_2
20
hasNotFiredRule
Extubation_1
15
isValid
EtCO2
0
hasNotFiredRule
Ventilation_1
30
in
mean
EtCO2
1
30
EtCO2_wean\normal
in
EtCO2
EtCO2_wean\normal
in
TVex
TVex\normal
then
Set output values
FiO2
PIP
PEEP
dPIP
[%]
[mbar]
[mbar]
-3
Display message
Weaning_:Ventilation im Normalbereich
Block / unblock groups and rules
< no group >
Meßfehler_1
Meßfehler_2
Ventilation_1
Ventilation_2
Ventilation_3
Oxygenierung_1
Oxygenierung_2
Oxygenierung_3
Extubation_1
inv_PIP
Anstieg_EtCO2
Block
= minute(s)
= until unblocked
Unblock
Don't change
Set mode of operation
< no change >
General settings
Variables
Fuzzy sets
Groups + Rules
Rules (detailed)

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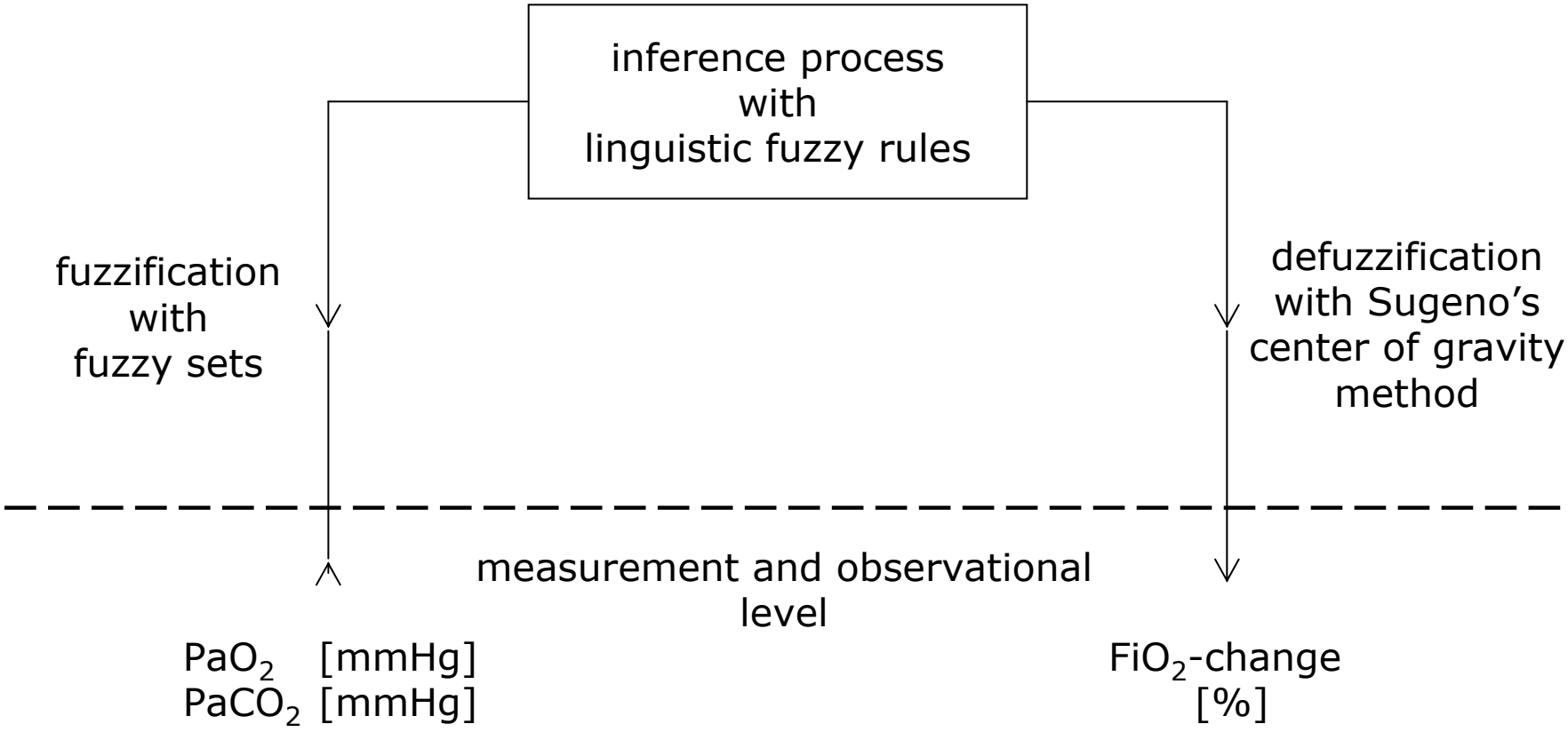
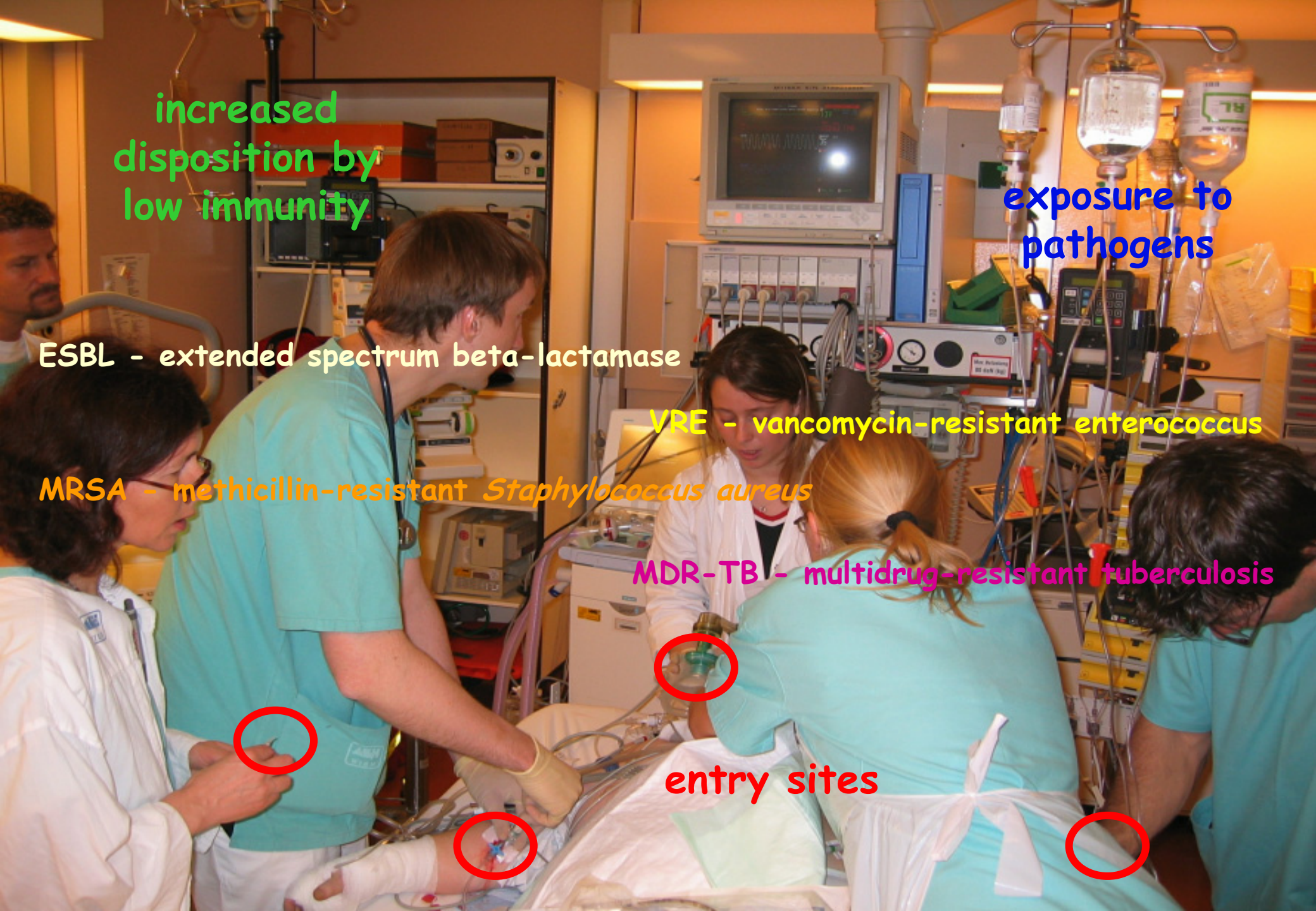
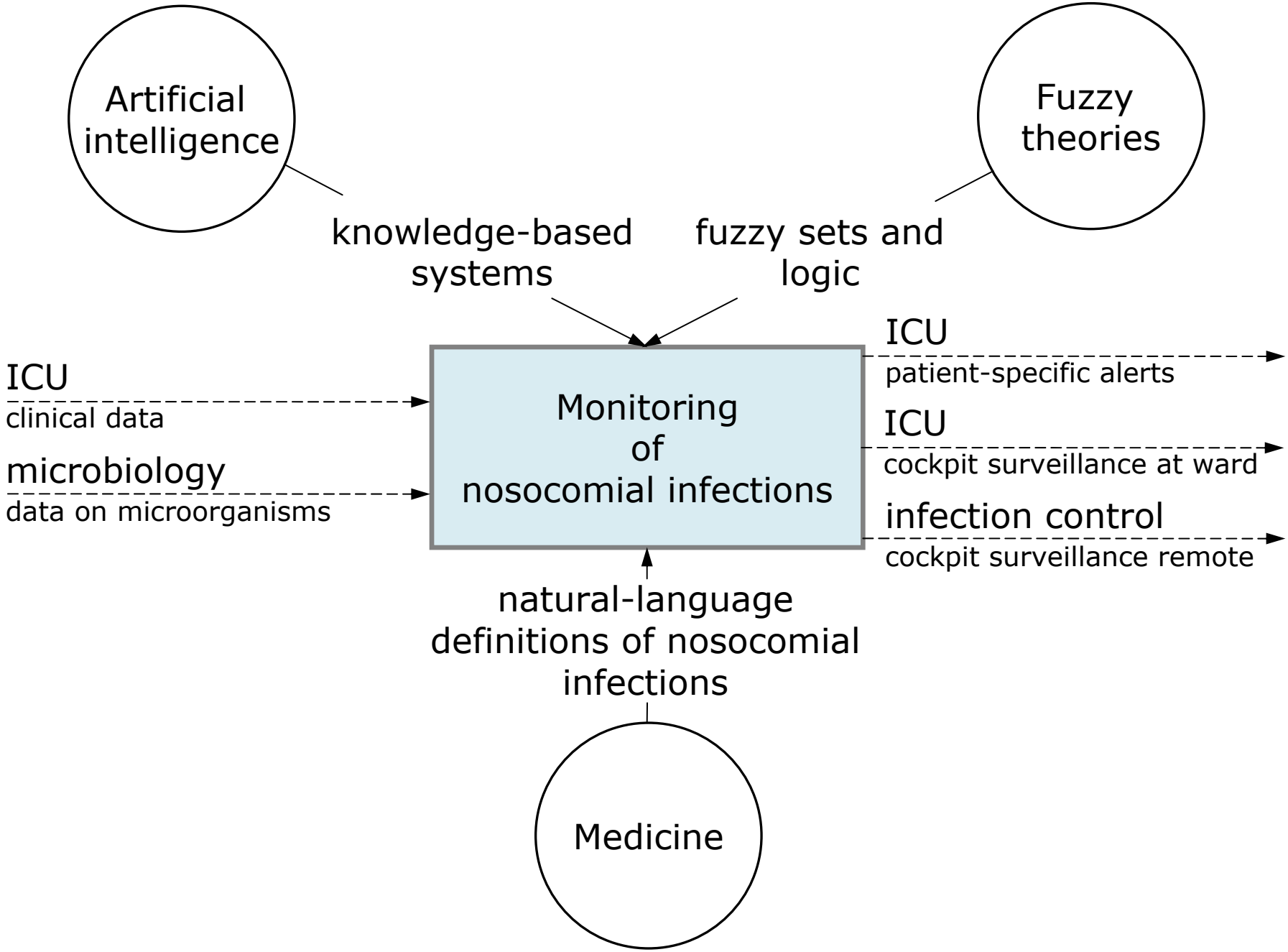
Fuzzy control




increased disposition by low immunity
exposure to pathogens
ESBL - extended spectrum beta-lactamase
VRE - vancomycin-resistant enterococcus
MRSA - methicillin-resistant *Staphylococcus aureus*
MDR-TB - multidrug-resistant tuberculosis
entry sites


Artificial intelligence
Fuzzy theories
knowledge-based systems
fuzzy sets and logic
ICU
clinical data
microbiology
data on microorganisms
Monitoring of nosocomial infections
ICU
patient-specific alerts
ICU
cockpit surveillance at ward
infection control
cockpit surveillance remote
natural-language definitions of nosocomial infections
Medicine

INFECTION SITE: Symptomatic urinary tract infection

CODE: UTI-SUTI

DEFINITION: A symptomatic urinary tract infection must meet at least one of the following criteria:

Criterion 1: Patient has at least *one* of the following signs or symptoms with no other recognized cause: fever (>38° C), urgency, frequency, dysuria, or suprapubic tenderness
and
patient has a positive urine culture, that is, $\geq 10^5$ microorganisms per cm^3 or urine with no more than two species of microorganisms.

Criterion 2: Patient has at least *two* of the following signs or symptoms with no other recognized cause: fever (>38° C), urgency, frequency, dysuria, or suprapubic tenderness
and
at least *one* of the following:

a. positive dipstick for leukocyte esterase and/or nitrate
b. pyuria (urine specimen with ≥ 10 wbc/mm^3 or ≥ 3 wbc/high power field of unspun urine)
c. organisms seen on Gram stain of unspun urine
d. at least *two* urine cultures with repeated isolation of the same uropathogen (gram-negative bacteria or *S. saprophyticus*) with $\geq 10^2$ colonies/ml in nonvoided specimens
e. $\leq 10^5$ colonies/ml of a single uropathogen (gram-negative bacteria or *S. saprophyticus*) in a patient being treated with an effective antimicrobial agent for a urinary tract infection
f. physician diagnosis of a urinary tract infection
g. physician institutes appropriate therapy for a urinary tract infection.

Criterion 3: Patient ≤1 year of age has at least *one* of the following signs or symptoms with no other recognized cause: fever (>38° C), hypothermia (<37° C), apnea, bradycardia, dysuria, lethargy, or vomiting
and
patient has a positive urine culture, that is, $\geq 10^5$ microorganisms per cm^3 of urine with no more than two species of microorganisms.

Criterion 4: Patient ≤1 year of age has at least *one* of the following signs or symptoms with no other recognized cause: fever (>38° C), hypothermia (<37° C), apnea, bradycardia, dysuria, lethargy, or vomiting
and
at least *one* of the following:

a. positive dipstick for leukocyte esterase and/or nitrate
b. pyuria (urine specimen with ≥ 10 wbc/mm^3 or >3 wbc/high power field of unspun urine)
c. organisms seen on gram stain or unspun urine
d. at least *two* urine cultures with repeated isolation of the same uropathogen (gram-negative bacteria or *S. saprophyticus*) with $\geq 10^2$ colonies/ml in nonvoided specimens
e. $\leq 10^5$ colonies/ml of a single uropathogen (gram-negative bacteria or *S. saprophyticus*) in a patient being treated with an effective antimicrobial agent for a urinary tract infection
f. physician diagnosis of a urinary tract infection
g. physician institutes appropriate therapy for a urinary tract infection.

COMMENTS:

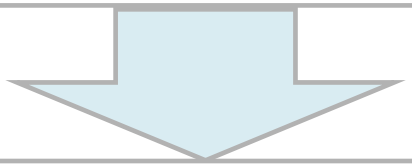
- A positive culture of a urinary catheter tip is *not* an acceptable laboratory test to diagnose a urinary tract infection.
- Urine cultures must be obtained using appropriate technique, such as clean catch collection or catheterization.
- In infants, a urine culture should be obtained by bladder catheterization or suprapubic aspiration; a positive urine culture from a bag specimen is unreliable and should be confirmed by a specimen aseptically obtained by catheterization or suprapubic aspiration.

Reprinted from: Garner JS, Jarvis WR, Emori TG, Horan TC, Hughes JM. CDC definitions for nosocomial infections. In: Olmsted RN, ed.: APIC Infection Control and Applied Epidemiology: Principles and Practice. St. Louis: Mosby; 1996: pp. A-1--A-20.

Bloodstream infection with clinical signs and growth of same skin contaminant from two separate blood samples

- Patient has at least one of the following signs or symptoms: fever (>38°C.), chills, or hypotension and 2 positive blood cultures for a common skin contaminant (from 2 separate blood samples drawn within 48 hours).

skin contaminants = coagulase-negative staphylococci, *Micrococcus sp., Propionibacterium acnes, Bacillus sp., Corynebacterium sp.*



BSI-A2

1

$\Leftarrow$

clinical_signs_of_BSI (t-1d, t, t+1d)

$\wedge$

same_skin_contaminant_from_two_separate_blood_samples

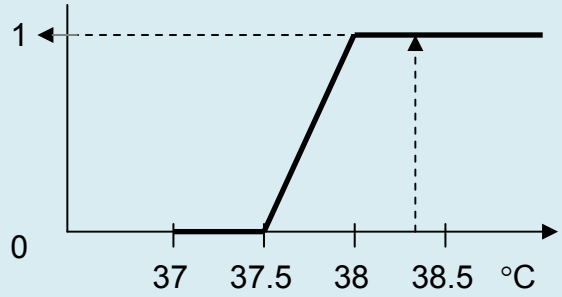
Decomposition—clinical signs

```
clinical_signs_of_BSI (t-1d, t, t+1d)[yesterday, today, tomorrow]

             =

                                                                  ⎛ fever (t-1d)
                                                                  ⎜       ∨
                                                                  ⎜ hypotension (t-1d)
                                                                  ⎜       ∨
clinical_signs_of_BSI (t-1d)                 =                    ⎜ leucopenia (t-1d)
                                                                  ⎜       ∨
                                                                  ⎜ leucocytosis (t-1d)
                                                                  ⎜       ∨
                                                                  ⎝ CRP increased (t-1d)
             ∨
                                                                  ⎛ fever (t)
                                                                  ⎜       ∨
                                                                  ⎜ hypotension (t)
                                                                  ⎜       ∨
clinical_signs_of_BSI (t)                    =                    ⎜ leucopenia (t)
                                                                  ⎜       ∨
                                                                  ⎜ leucocytosis (t)
                                                                  ⎜       ∨
                                                                  ⎝ CRP increased (t)
             ∨
                                                                  ⎛ fever (t+1d)
                                                                  ⎜       ∨
                                                                  ⎜ hypotension (t+1d)
                                                                  ⎜       ∨
clinical_signs_of_BSI (t+1d)                 =                    ⎜ leucopenia (t+1d)
                                                                  ⎜       ∨
                                                                  ⎜ leucocytosis (t+1d)
                                                                  ⎜       ∨
                                                                  ⎝ CRP increased (t+1d)
```

Clinical signs—fever

fever (t-1d) ⇐ ...

fever (t) ⇐ { body temperature ↑ ∨ thermoregulation applied ...



data import

intensive care unit

[maximum value of the day e.g., 38.5 °C]

fever (t+1d) ⇐ ...

MED Intensiv : PatientenNameNummer 1,70m2 62,00kg

Hauptmenü | Aktionen | Anzeige | Bericht | DATENEINGABE

GRAFIK | ÜBER-SICHT | NEURO/STATUS | ATMUNG | MED./BILANZ | SPEZ.THERAP | PFLEGE | SPEZ.PFLEGE | KATH./SONDEN | OP-WU/DRAIN | LABOR1 | LABOR2 | NIERE | HÄMODY-NAMIK | SCORES

	Zeit: 4 h Autom. Dokument. @30mi	1800	2200	06Juli05 0200	0600	1000	06Juli05 1400	1800	2200	07Juli05 0200	0600	1000	07Juli05 1400
Allerg	Katheter/Sonde					✳ ZVK 1							
	Ereignis: Was?					✳ gelegt							
	Ereignis: Wer?					✳ kos.							
ZVK	ZVK 1: Zugang					▷re Scl.	re Scl.	re Scl.		re Scl.	▷re Scl.	re Scl.	re Scl.
	ZVK 1: Tag/Lumen					▷ 1 4-lu	1 4-lu	1 4-lu		1 4-lu	▷ 2 4-lu	2 4-lu	2 4-lu
	ZVK 1: Befund												
	ZVK 1: Rein./Desinf.					▷0,9/ SH							
	ZVK 1: Versorgung					▷ Stand.	Stand.	Stand.		Stand.	▷ Stand.	Folie	Folie
	ZVK 1: Versorg. seit					▷ 6 Juli	6 Juli	6 Juli		6 Juli	▷ 6 Juli	7 Juli	7 Juli
	ZVK 1: Kontrolle												
	ZVK 2: Zugang	✳li Scl.		li Scl.	✳li Scl.	li Scl.							
	ZVK 2: Tag/Lumen	✳14 3-lu		14 3-lu	✳14 3-lu	15 3-lu							
	ZVK 2: Befund			gerötet	gerötet	gerötet							
	ZVK 2: Rein./Desinf.												
	ZVK 2: Versorgung	✳ Folie		Folie	✳ Folie	✳ Folie	Druckvb	Druckvb		Druckvb	▷Druckvb		
	ZVK 2: Versorg. seit	✳28 Juni		28 Juni	✳28 Juni	✳28 Juni	6 Juli	6 Juli		6 Juli	▷ 6 Juli		
	ZVK 2: Kontrolle				▷Röntgen								
Arter	Art.2: Zugang	✳li fem.		li fem.	✳li fem.	li fem.							
	Art.2: Tag/Typ	✳22 G16L		22 G16L	✳22 G16L	23 G16L							
	Art.2: Befund				gerötet	gerötet							
	Art.2: Rein./Desinf.												
	Art.2: Versorgung	✳ Folie		Folie	✳ Folie	✳ Folie	Druckvb	Druckvb		Druckvb	▷Druckvb		
	Art.2: Versorg. seit	✳ 2 Juli		2 Juli	✳ 2 Juli	✳ 2 Juli	6 Juli	6 Juli		6 Juli	▷ 6 Juli		
Harn	Harnabl.2: Tag/Typ	✳ 9 DK		9 DK	✳ 9 DK	9 DK	9 DK	9 DK		9 DK	▷10 DK	10 DK	10 DK
	HarnK.2: Ch/Material	✳16 Sili		16 Sili	✳16 Sili	17 Sili	17 Sili	17 Sili		17 Sili	▷17 Sili	17 Sili	17 Sili
	HarnK.2: Befund					oB.							
	HarnK.2: Rein/Desinf					Std/							
	HarnK.2: Versorgung	✳ Schutz		Schutz	✳ Schutz		Schutz	Schutz		Schutz	▷ Schutz	Schutz	Schutz
	HarnK.2:Versorg.seit	✳30 Juni		30 Juni	✳30 Juni	30 Juni	30 Juni	30 Juni		30 Juni	▷30 Juni	30 Juni	30 Juni
Enter	EntSonde2: Tag/Lokal	✳25 nasL		25 nasL	✳25 nasL	26 nasL	26 nasL	26 nasL		26 nasL	▷27 nasL	27 nasL	27 nasL
	EntSonde2: Ch/Typ	✳15 MaSi		15 MaSi	✳15 MaSi	15 MaSi	15 MaSi	15 MaSi		15 MaSi	▷15 MaSi	15 MaSi	15 MaSi
	EntSonde2: Kontrolle												
	EntSonde2: Befund				oB.								
	EntSonde2: Fixation	✳Pfl+Pol		Pfl+Pol	✳Pfl+Pol	Pfl+Pol	Pfl+Pol	Pfl+Pol		Pfl+Pol	▷Pfl+Pol	Pfl+Pol	Pfl+Pol
PM	PM: Tag/Zugang	✳40 Vent		40 Vent	40 Vent			▷41 Vent		41 Vent	▷42 Vent	42 Vent	42 Vent
	PM: Befund												
	PM: Rein/Desinf.												
	PM: Versorgung	✳ Stand.		Stand.	Stand.			▷ Stand.		Stand.	▷ Stand.	Stand.	Stand.
	PM: Versorg. seit	✳ 5 Juli		5 Juli	5 Juli			▷ 5 Juli		5 Juli	▷ 5 Juli	5 Juli	5 Juli

07 Juli 05 1513

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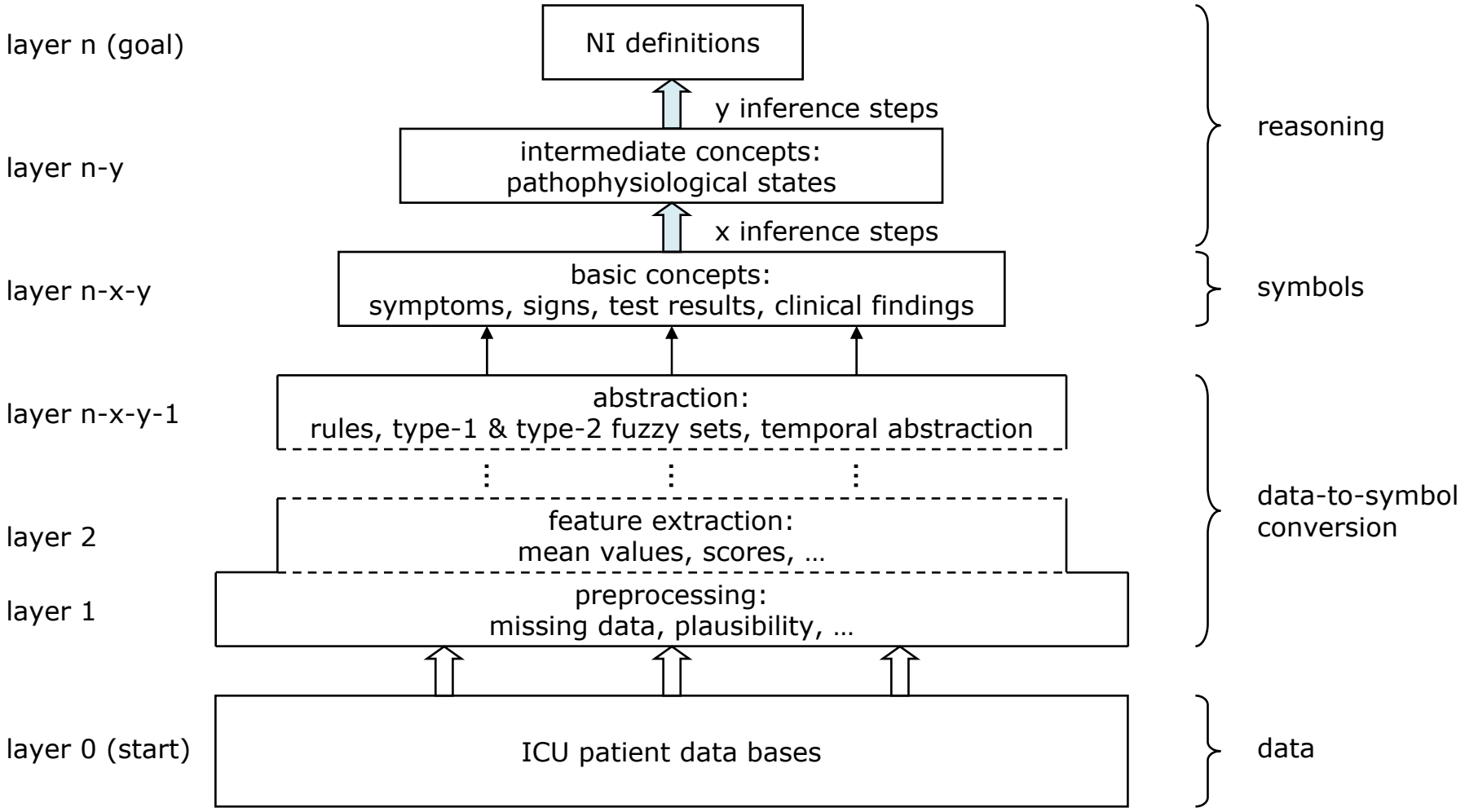
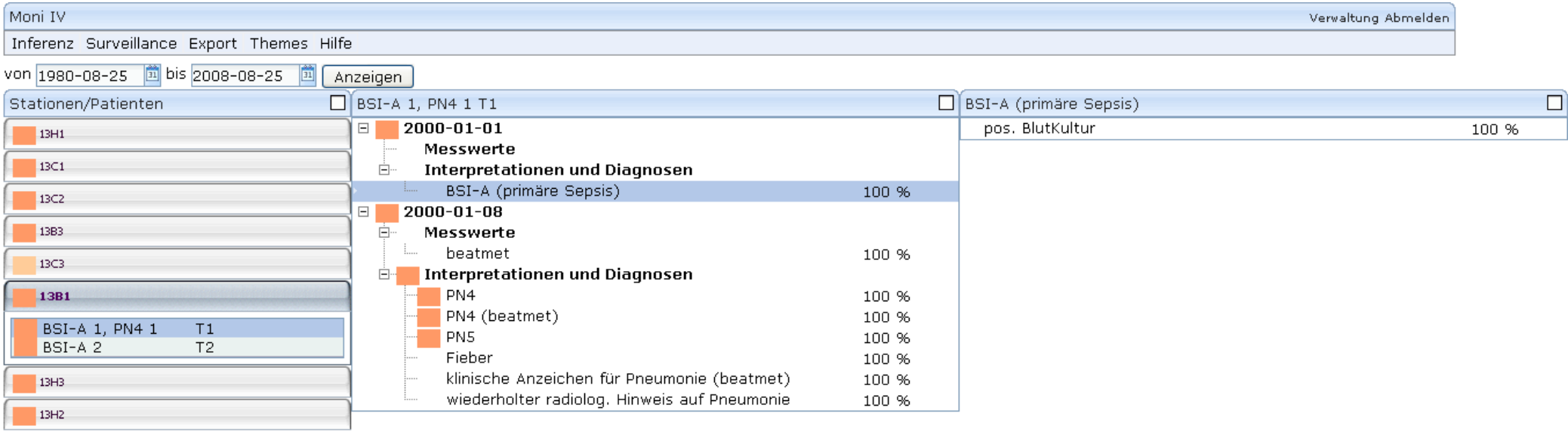
Processing layers



Cockpit surveillance at the infection control unit: Three criteria-based definitions in two patients are completely fulfilled (100%), backtracking of the logical chain of reasoning is provided ...



… down to the level of detailed clinical and laboratory findings

Moni IV Verwaltung Abmelden

Inferenz Surveillance Export Themes Hilfe

von 1980-08-25 bis 2008-08-25 Anzeigen

BSI-A (primäre Sepsis)

Regel: BSI-A.1 (Regelgewicht: 100 %)

Parameter	Wert	Station	ermittelt	Urheber	Anmerkung
BSI-A (primäre Sepsis)	1.0	13B1	Aug 25, 2008 10:34:22 AM	[mxt]	

Bedingungen

Parameter	Wert	Station	ermittelt	Urheber	Anmerkung
pos. BlutKultur	100 %	13B1		mibi. Import	none; Blut; E. Coli. 10^6 KBE/ml

BSI-A (primäre Sepsis) trifft zu, wenn ein kultureller Nachweis von pathogenen Erregern im Blut vorliegt, die nicht in anderem Material zu finden sind.

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Arden and Health Level Seven (HL7)

- A standard language for writing situation-action rules that can trigger alerts based on abnormal clinical events detected by a clinical information system.

  van Bemmel, J.H., Musen, M.A. (eds.) (1997)
  Handbook of Medical Informatics, Springer-Verlag,
  Heidelberg, Glossary, p. 559.

- Each module, referred to as a Medical Logic Module (MLM), contains sufficient knowledge to make a single decision.

  extended by packages of MLMs for complex clinical decision support

- Contraindication alerts, management suggestions, data interpretations, treatment protocols, and diagnosis scores are examples of the health knowledge that can be represented using MLMs.

  extended by single and differential diagnosis, temporal monitoring, control systems, selective computerized processing of clinical pathways and management guidelines

- The first version of the ARDEN syntax was administered and issued by the American Society for Testing and Materials ASTM (1992, version 1.0; today 2.5). Since 1998, an Arden Syntax Special Interest Group (SIG) is part of the HL7 organization (www.hl7.org).

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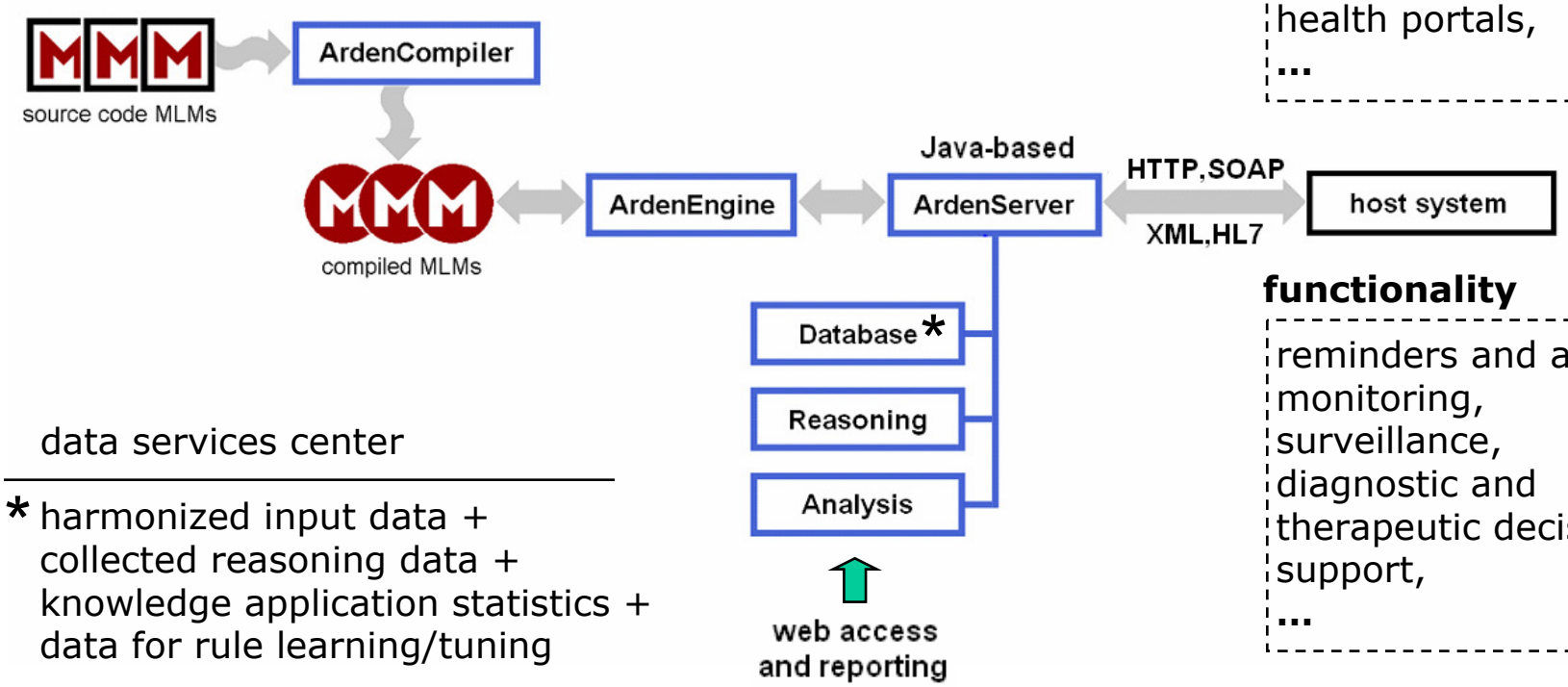
Arden, ArdenServer, and health care information systems



integration

HIS, MIS, PDMS, LIS, medical practice SW, web-based EHR, telemedicine applications, health portals, ...

functionality

reminders and alerts, monitoring, surveillance, diagnostic and therapeutic decision support, ...

data services center

* harmonized input data + collected reasoning data + knowledge application statistics + data for rule learning/tuning

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Significance of nosocomial infections

- 3 to 14% of patients admitted to acute care hospitals acquire one or more nosocomial infections
- in consequence, 5 to 7% of them die

Vienna General Hospital with 2,200 beds:

patients admitted to wards:	94,715
days of care:	688,619
average length of stay:	6.1 days
costs / patient / day:	EUR 678.-

- nosocomial infections: 4,262 patients / year (rate of 4.5% assumed)
- 213 out of them die / year (5% mortality assumed)
- additional costs of EUR 14,448,180.- (5 days of prolonged stay, in average)

source: Prof. Dr. med. Ojan Assadian, Division of Hospital Hygiene, Medical University of Vienna (2002)

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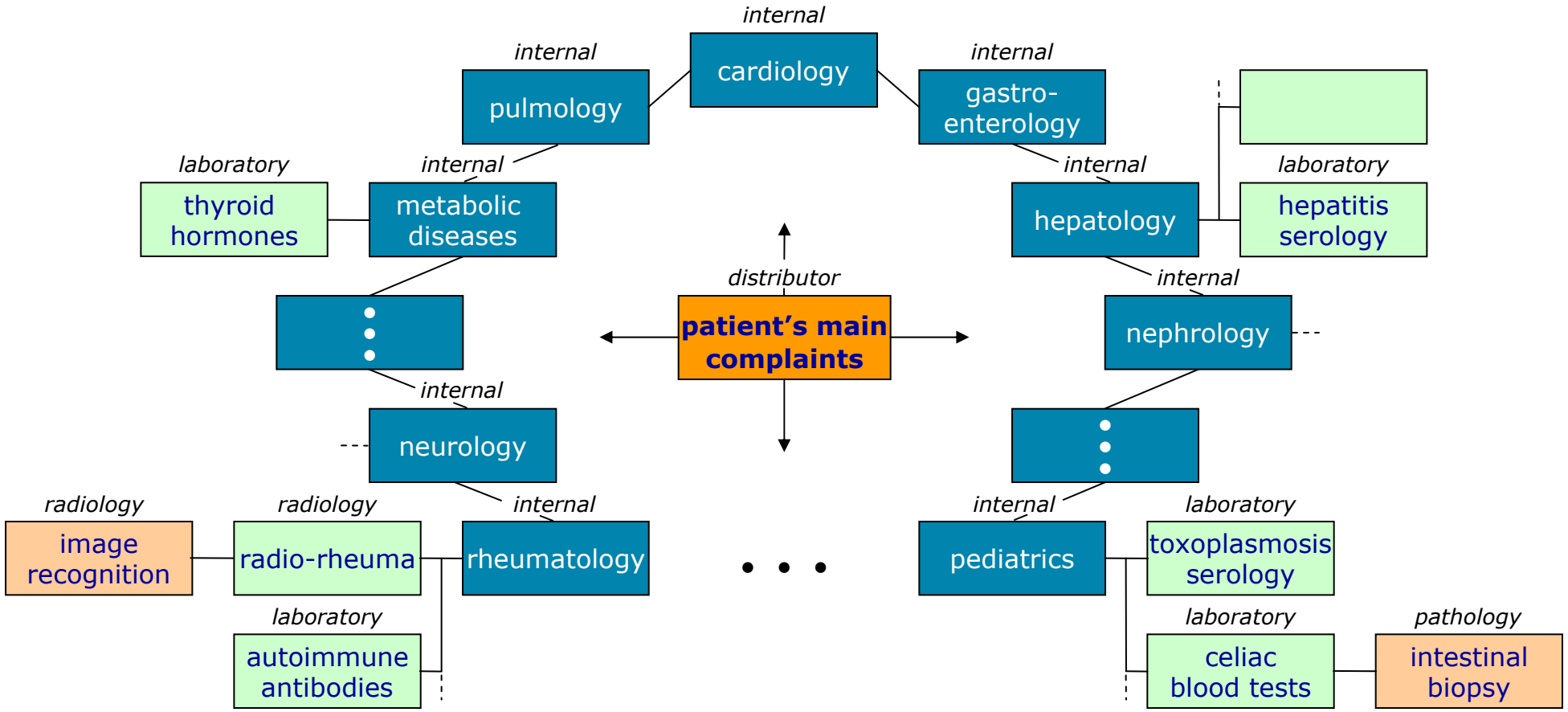
Cooperating computational intelligence in medicine–as a safety net for health care processes



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Towards a science of clinical medicine

patient's medical data and healthcare processes for human processing	≠	patient's medical data and healthcare processes for machine processing
observations e.g., temperature chart skin color (jaundice, livid, …) **…**		measurements e.g., CRP color measurement **…**

"Measure what is measurable, and make measurable what is not so."

Galileo Galilei
1564–1642

Crucial point in clinical medicine:

"Digitize what is digitizable, and make digitizable what is not so."

Klaus-Peter Adlassnig