Keeping Afloat

Updates and Horizons in the Cirrhotic Code

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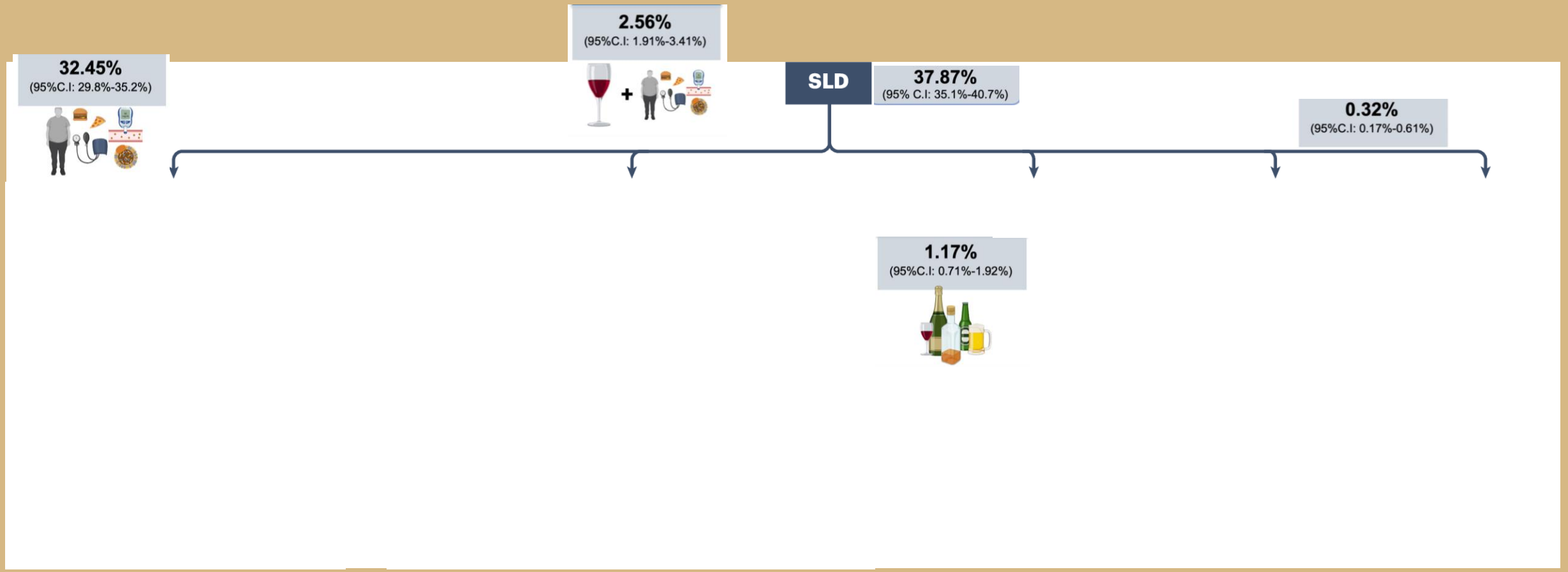
Learning Objectives

- Upon completion of this activity, participants will be able to :
  - Employ medication and nutrition focused strategies in the management of Hepatic Encephalopathy.
  - Apply risk stratification strategies according to new Perioperative Management guidelines.
  - Review the disconnect between current guidelines and evolving evidence for SBP prophylaxis.
  - Recognize the prevalence of fungal infections in chronic liver disease and the threat they pose.

Disclosures - none

- 28yoM w/ AUD c/b alcohol-related hepatitis admitted due to concern for decompensated cirrhosis. MELD-Na 30. Maddrey Discriminant Function 64. No evidence of infection. He is started on prednisolone 40mg daily. Day 4 Lille Score suggesting steroid responder. He is discharged a few days later to complete a 4 week course w/ subsequent taper off.

NHANES 2017-2020 Prevalence



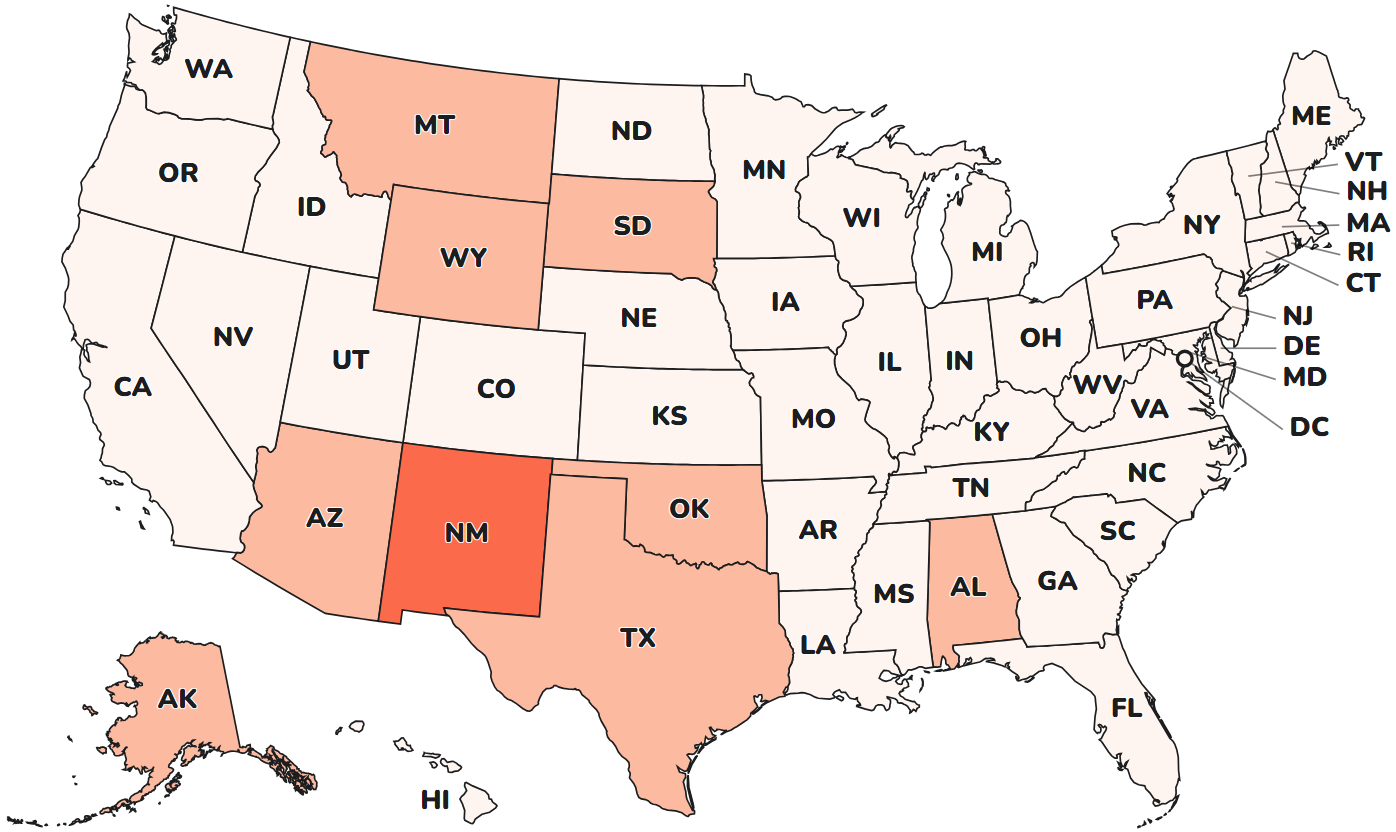
M*A*S*H

Chronic liver disease deaths per 100,000 total population (age-adjusted mortality rate)

- 6 - < 13.02
- 13.02 - < 20.04
- 20.04 - < 27.06
- 27.06 - < 34.08
- 34.08 - < 41.1

Year

2016



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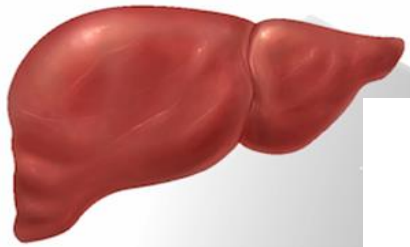
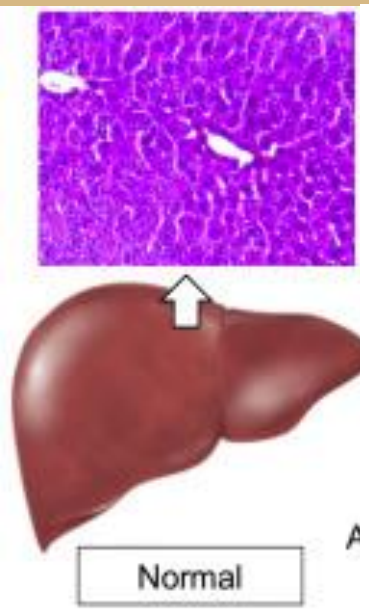
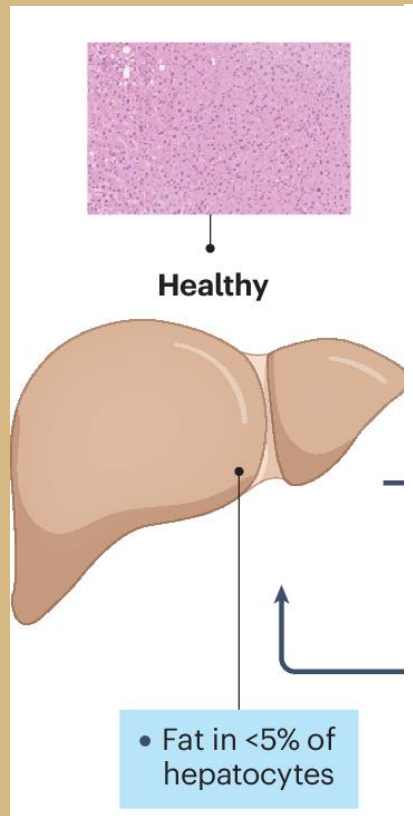
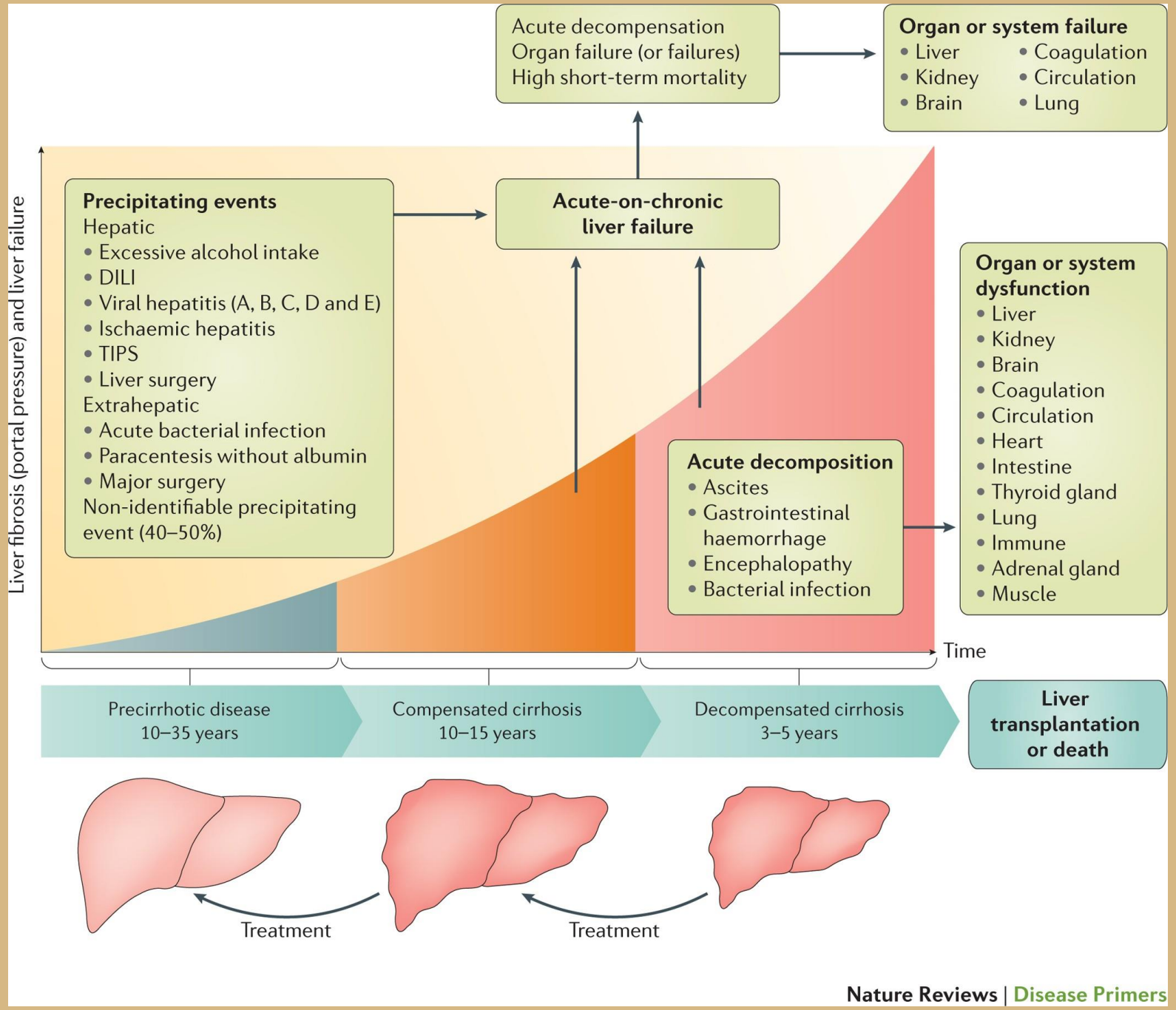
Normal Liver

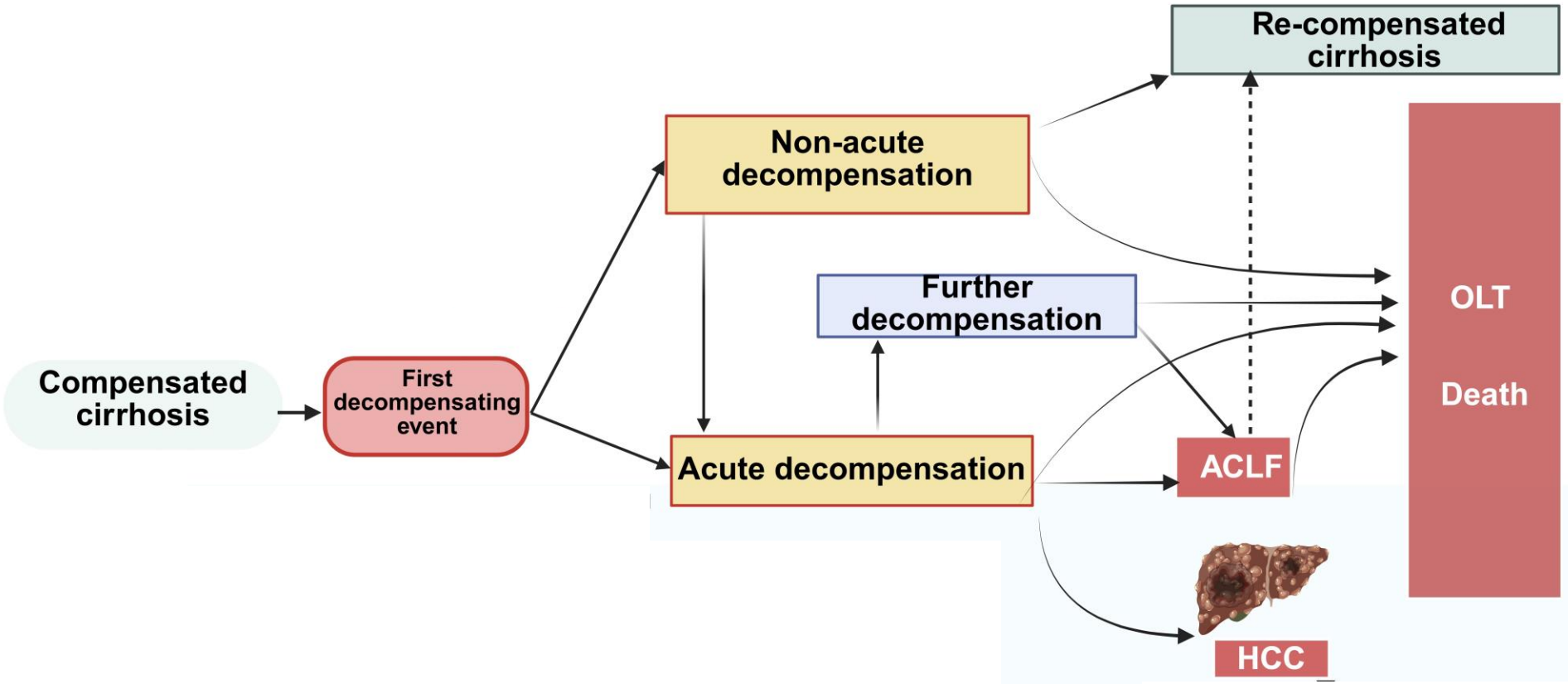


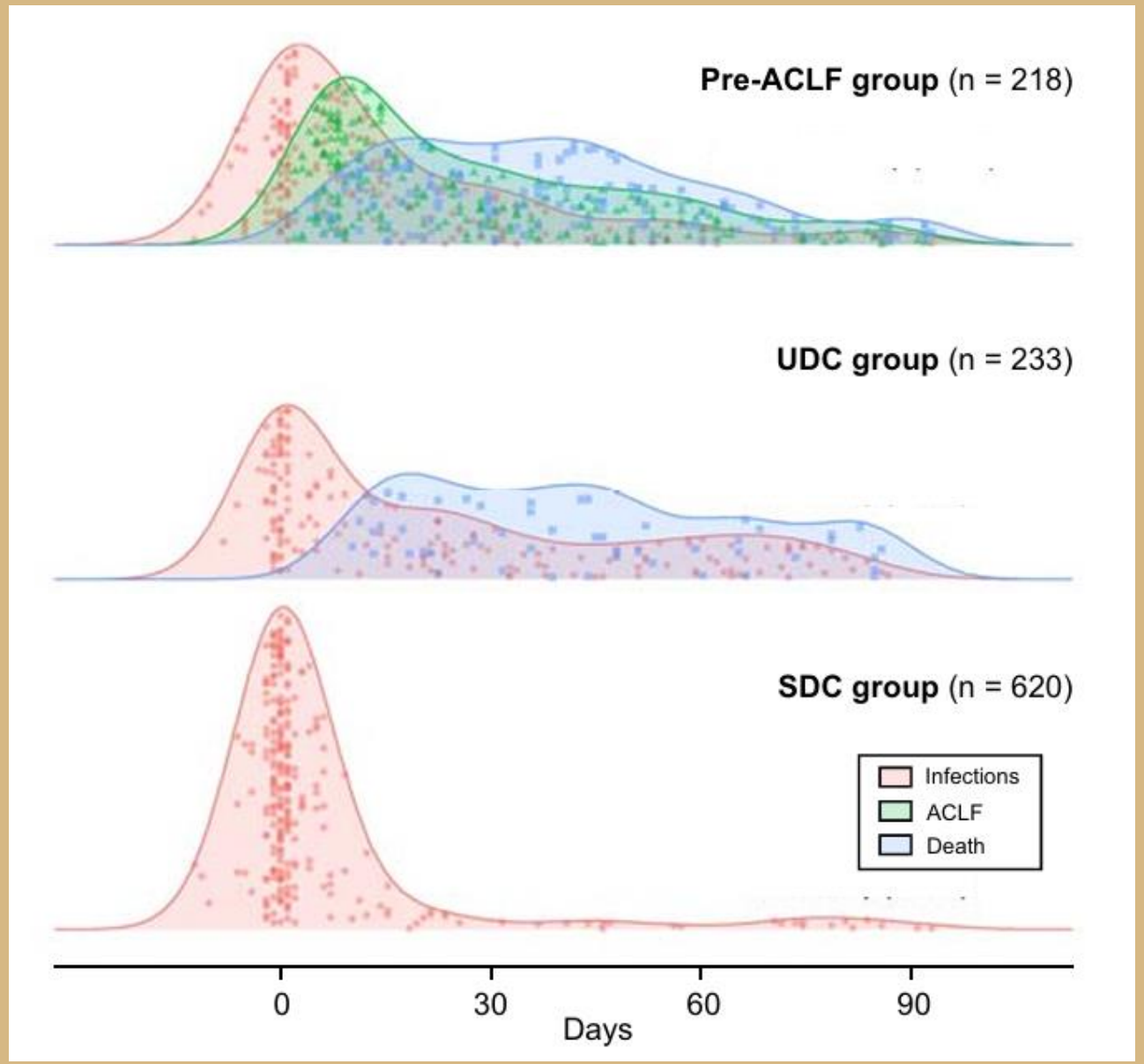
HCV Infection


Normal


Healthy
• Fat in <5% of hepatocytes


Acute decompensation
Organ failure (or failures)
High short-term mortality
Organ or system failure
• Liver
• Kidney
• Brain
• Coagulation
• Circulation
• Lung
Precipitating events
Hepatic
• Excessive alcohol intake
• DILI
• Viral hepatitis (A, B, C, D and E)
• Ischaemic hepatitis
• TIPS
• Liver surgery
Extrahepatic
• Acute bacterial infection
• Paracentesis without albumin
• Major surgery
Non-identifiable precipitating event (40–50%)
Acute-on-chronic liver failure
Acute decomposition
• Ascites
• Gastrointestinal haemorrhage
• Encephalopathy
• Bacterial infection
Organ or system dysfunction
• Liver
• Kidney
• Brain
• Coagulation
• Circulation
• Heart
• Intestine
• Thyroid gland
• Lung
• Immune
• Adrenal gland
• Muscle
Liver fibrosis (portal pressure) and liver failure
Time
Precirrhotic disease
10–35 years
Compensated cirrhosis
10–15 years
Decompensated cirrhosis
3–5 years
Liver transplantation or death
Treatment
Treatment
Nature Reviews | Disease Primers


Re-compensated cirrhosis
Non-acute decompensation
Further decompensation
OLT
Death
Compensated cirrhosis
First decompensating event
Acute decompensation
ACLF
HCC

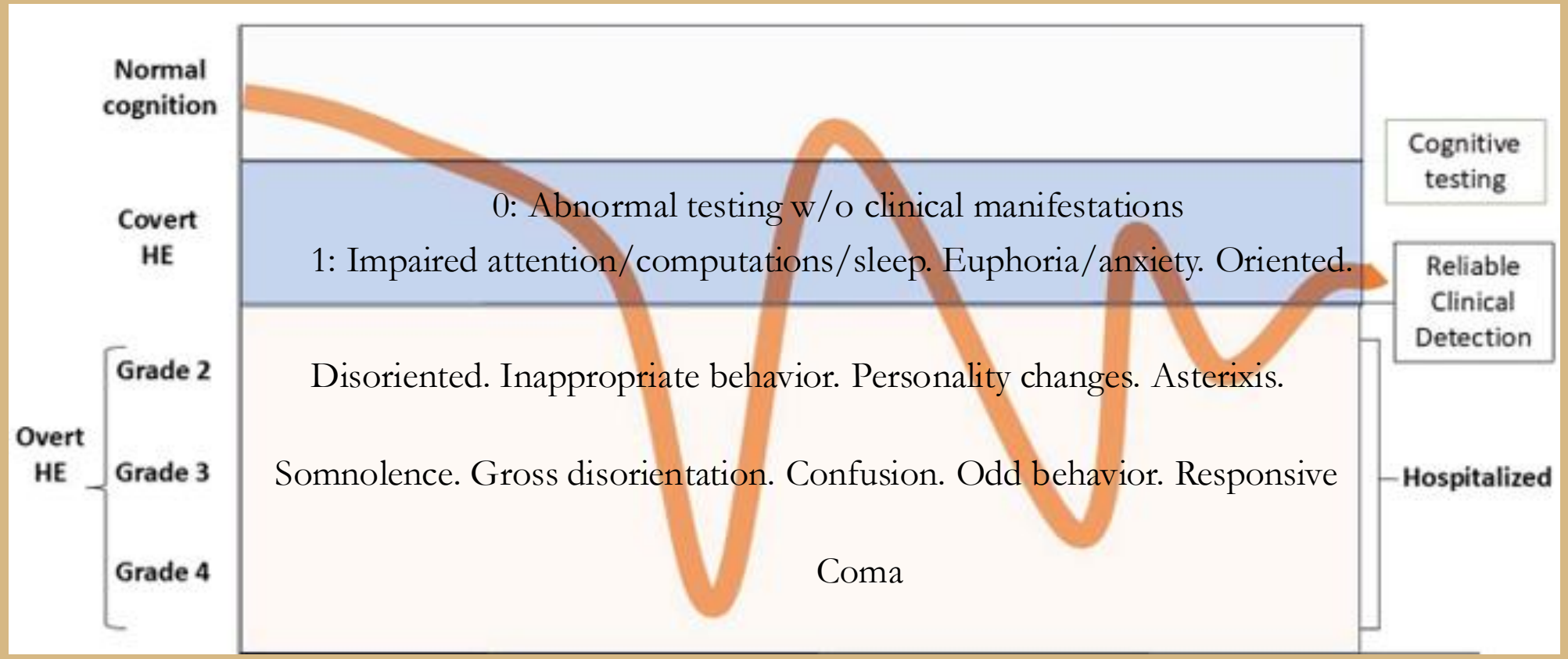

Pre-ACLF group (n = 218)
UDC group (n = 233)
SDC group (n = 620)
Infections
ACLF
Death
0
30
60
90
Days

New Guidelines

Hepatic Encephalopathy

ACG– Spring 2026

- Now the most common first decompensating event
  - 1-year incidence 10% of Child Pugh A
  - 1-year incidence 25% of Child Pugh B
  - 5-year incidence in decompensated cirrhosis estimated to be 40%
- Most common cause of readmission
  - 20-50% 90-d readmission rate
  - Admission cost ~$50k in 2017 and ~$20k monthly thereafter for 6 months
- Can cause Parkinsonian features (bradykinesia)
- Attention deficit (span + shift) + increased risk of fall, injury, worse @ cognition-related tasks, impaired productivity/learning
- Risk of aspiration pneumonia increased


Normal cognition
Covert HE
Overt HE
Grade 2
Grade 3
Grade 4
0: Abnormal testing w/o clinical manifestations
1: Impaired attention/computations/sleep. Euphoria/anxiety. Oriented.
Disoriented. Inappropriate behavior. Personality changes. Asterixis.
Somnolence. Gross disorientation. Confusion. Odd behavior. Responsive
Coma
Cognitive testing
Reliable Clinical Detection
Hospitalized

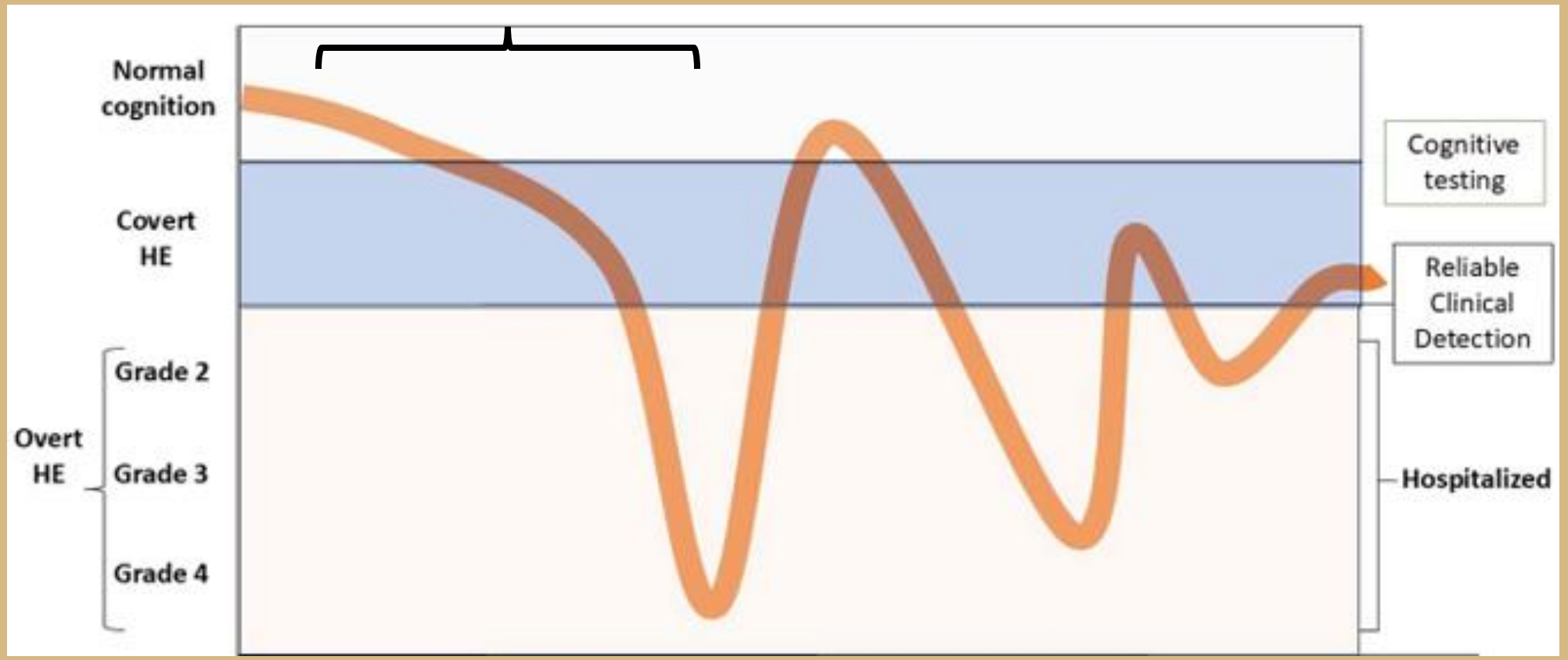
No Ammonia Testing

Opioids
Benzos
Z-Hypnotics

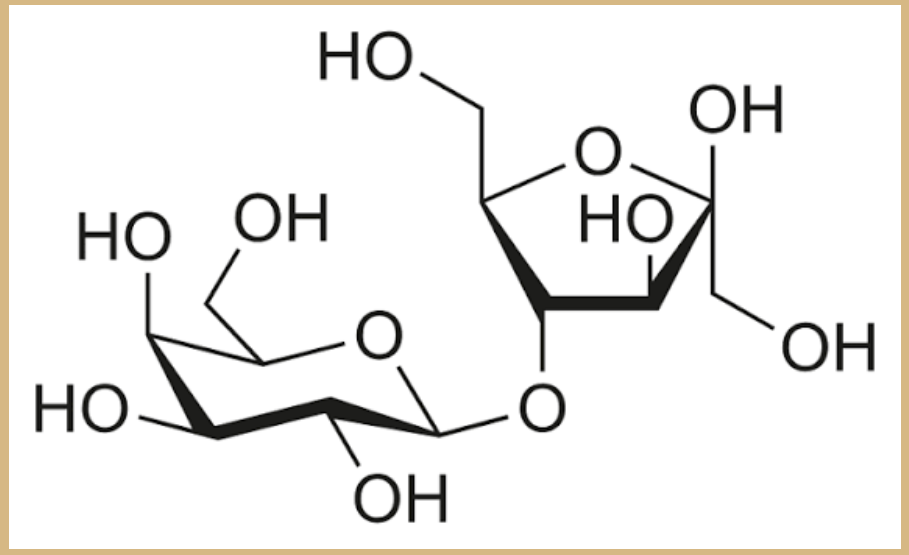
↑Na ↓K

PRECIPITANTS:
- AKI, electrolyte abnormalities
- Infection, GI bleeding
- Constipation or Ileus / SBO
- Discontinue/avoid sedatives

OTHER ETIOLOGY:
- Toxins/drugs, metabolic
- Intracranial process, neuroinfection
- Dementia, psychiatric disorder



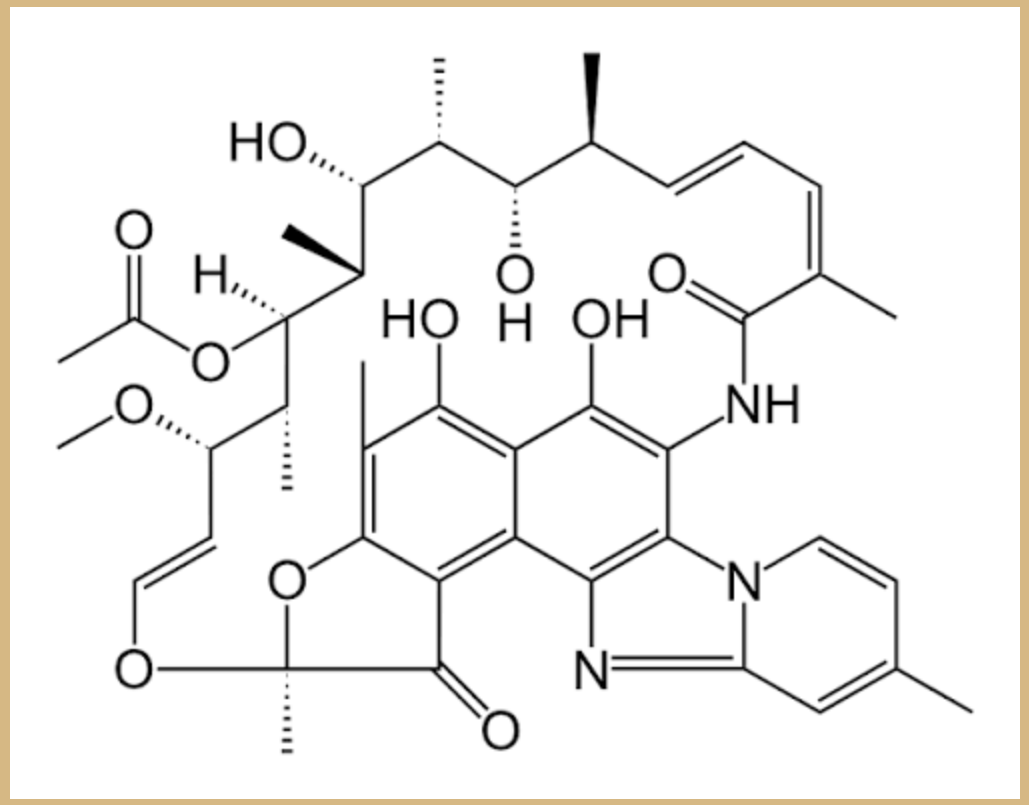
Dynamic Duo

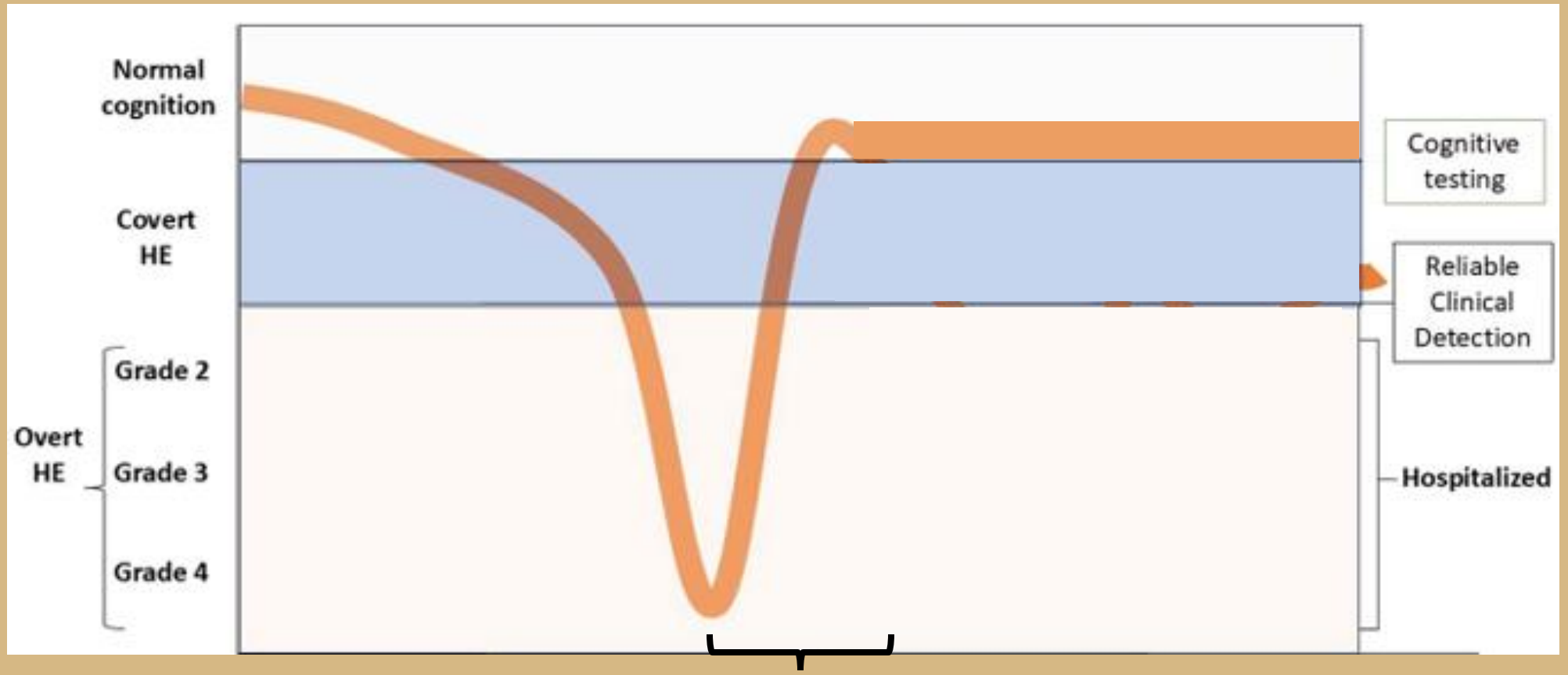


Lactulose

+

Rifaximin

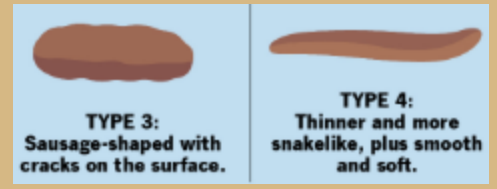


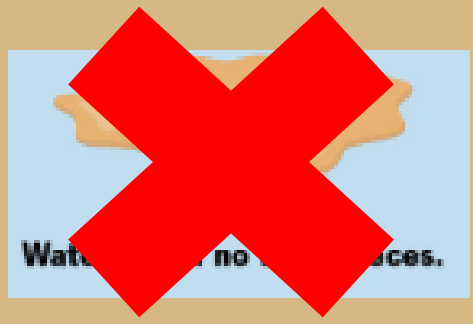


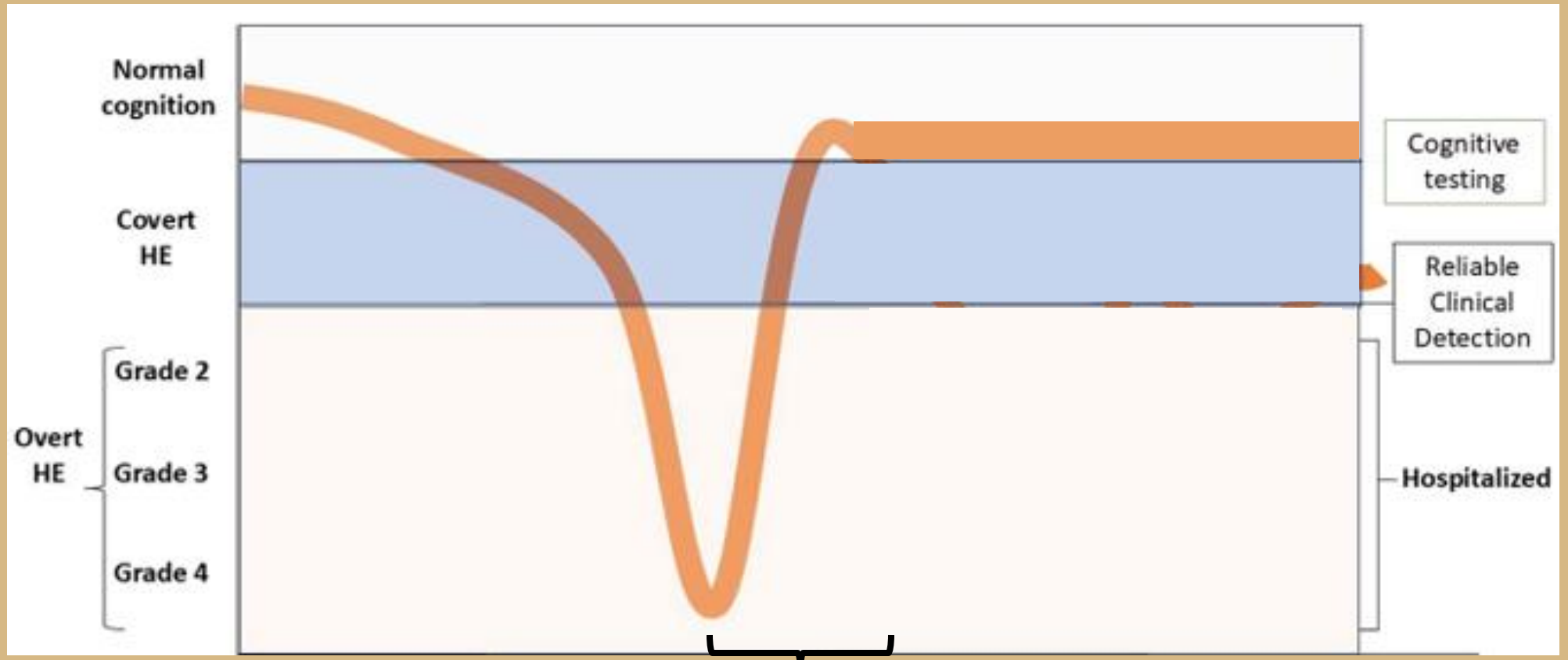
Lactulose

+

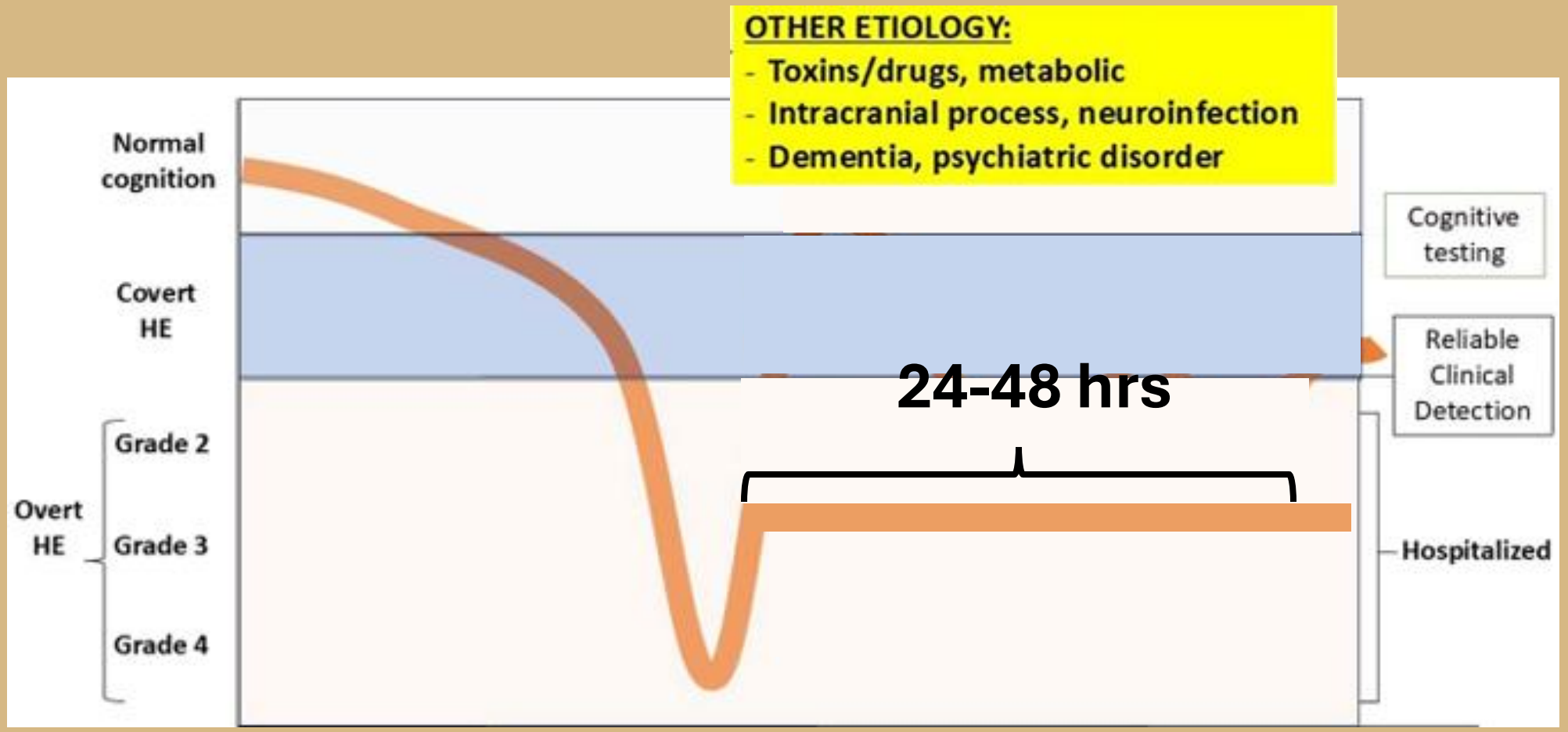
Rifaximin

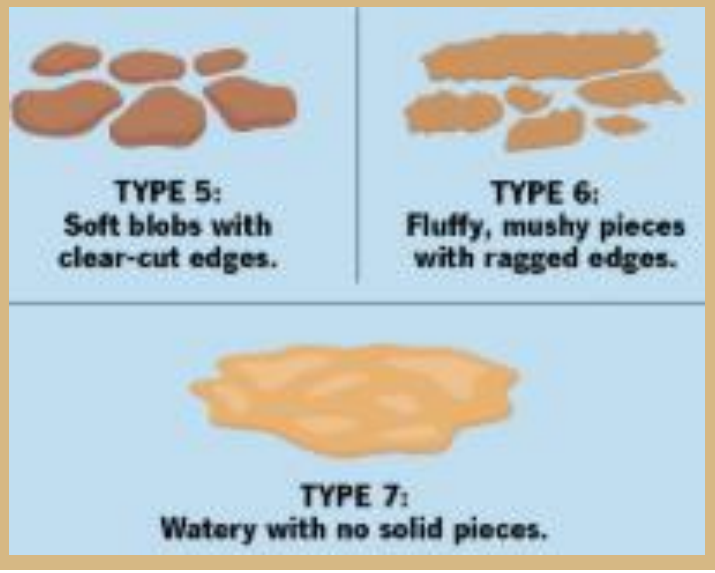
→ **2-3** [] **Daily**





High-volume PEG3350 **>** **Mag Salts**

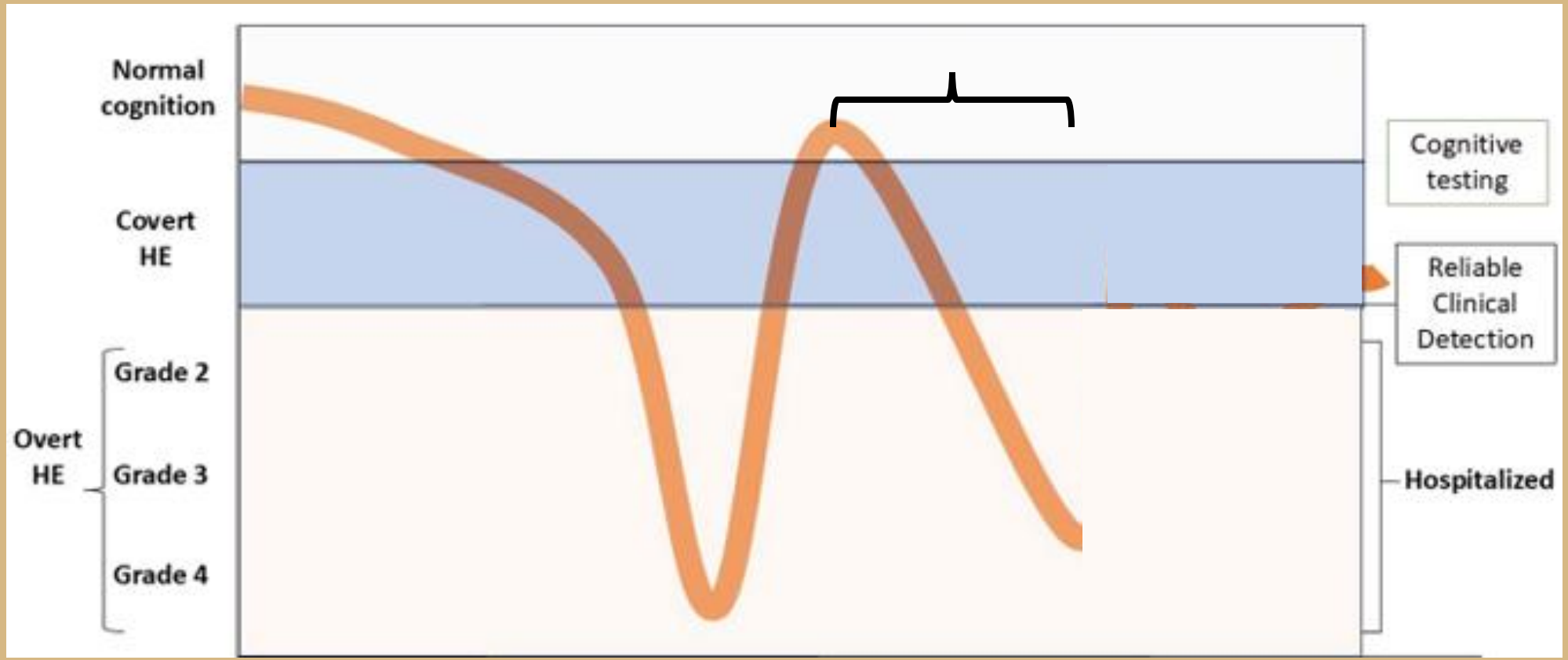

OTHER ETIOLOGY:
- Toxins/drugs, metabolic
- Intracranial process, neuroinfection
- Dementia, psychiatric disorder
Normal cognition
Covert HE
Overt HE
Grade 2
Grade 3
Grade 4
24-48 hrs
Cognitive testing
Reliable Clinical Detection
Hospitalized



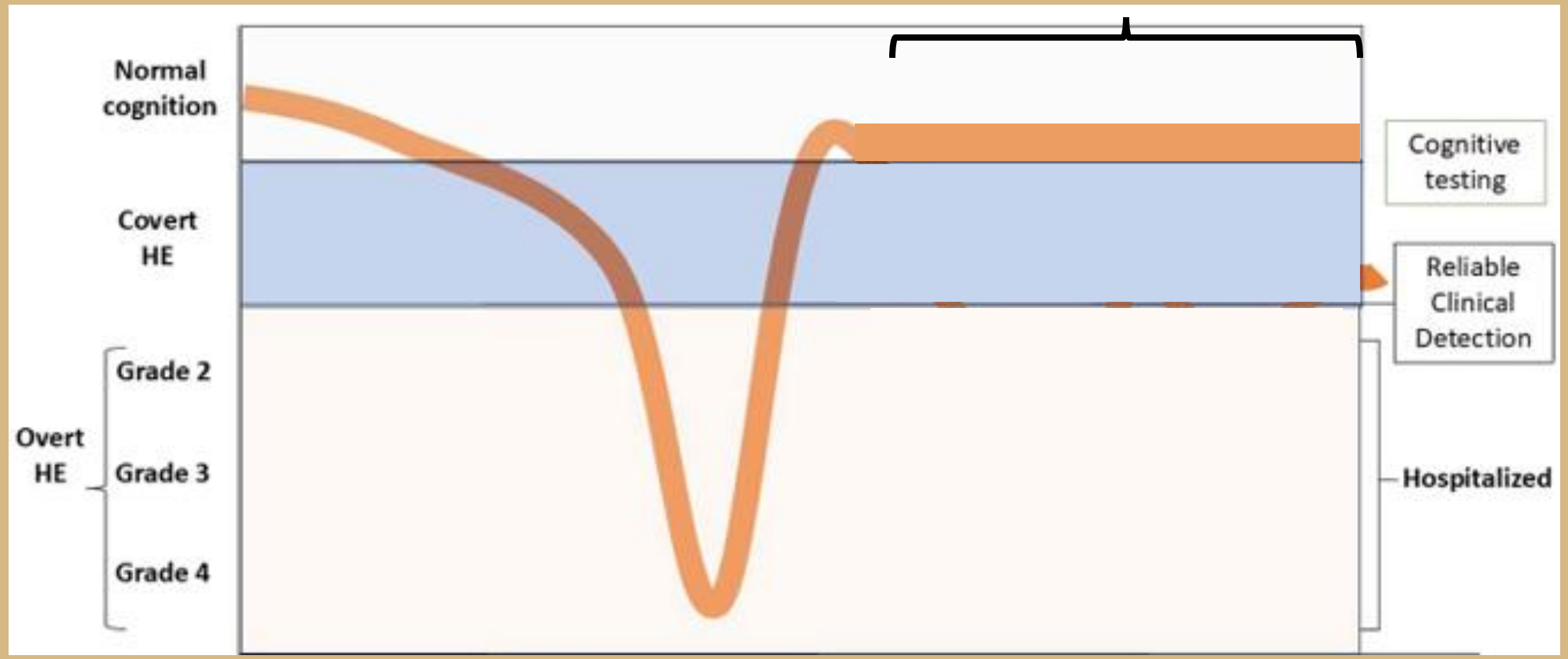
1 - noncompliance

2 - dehydration

3 – spontaneous porto-systemic shunt



Lactulose + Rifaximin



(Mal)Nutrition

ACG – Spring 2025

ASPEN Criteria

TABLE 2 Characteristics to diagnose moderate malnutrition

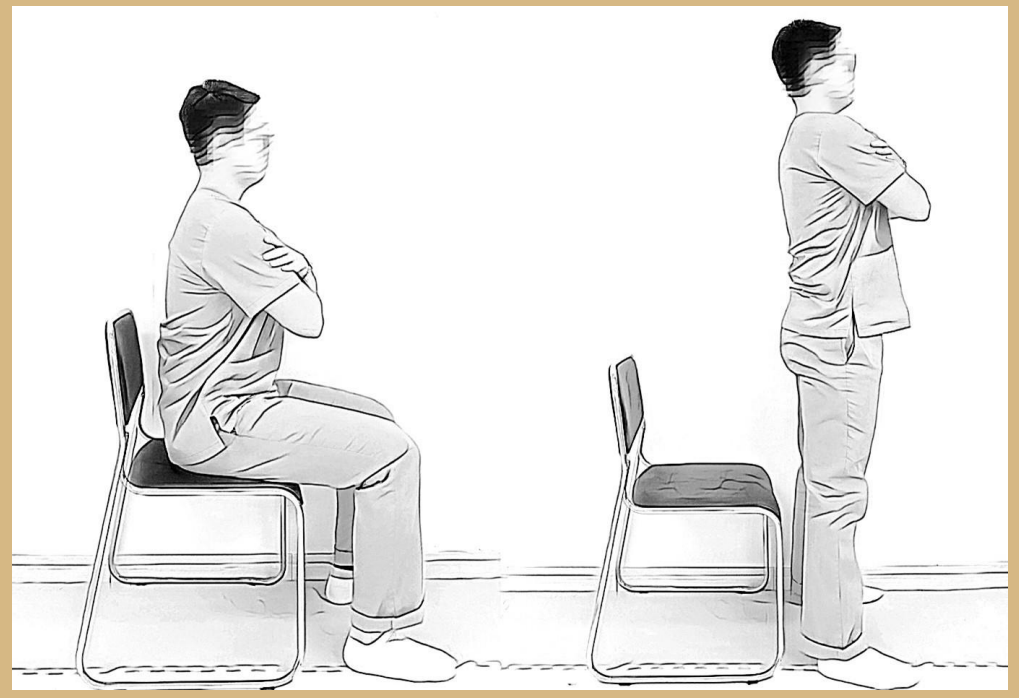
Characteristic	Acute illness– or injury-related malnutrition	Chronic disease–related malnutrition
Weight loss	1%–2% in 1 week, 5% in 1 month, or 7.5% in 3 months	5% in 1 month, 7.5% in 3 months, 10% in 6 months, or 20% in 1 year
Energy intake	<75% for >7 days	<75% for ≥ 1 month
Body fat	Mild depletion	Mild depletion
Muscle mass	Mild depletion	Mild depletion
Fluid accumulation	Mild	Mild
Grip strength	Not applicable	Not applicable

TABLE 3 Characteristics to diagnose severe malnutrition

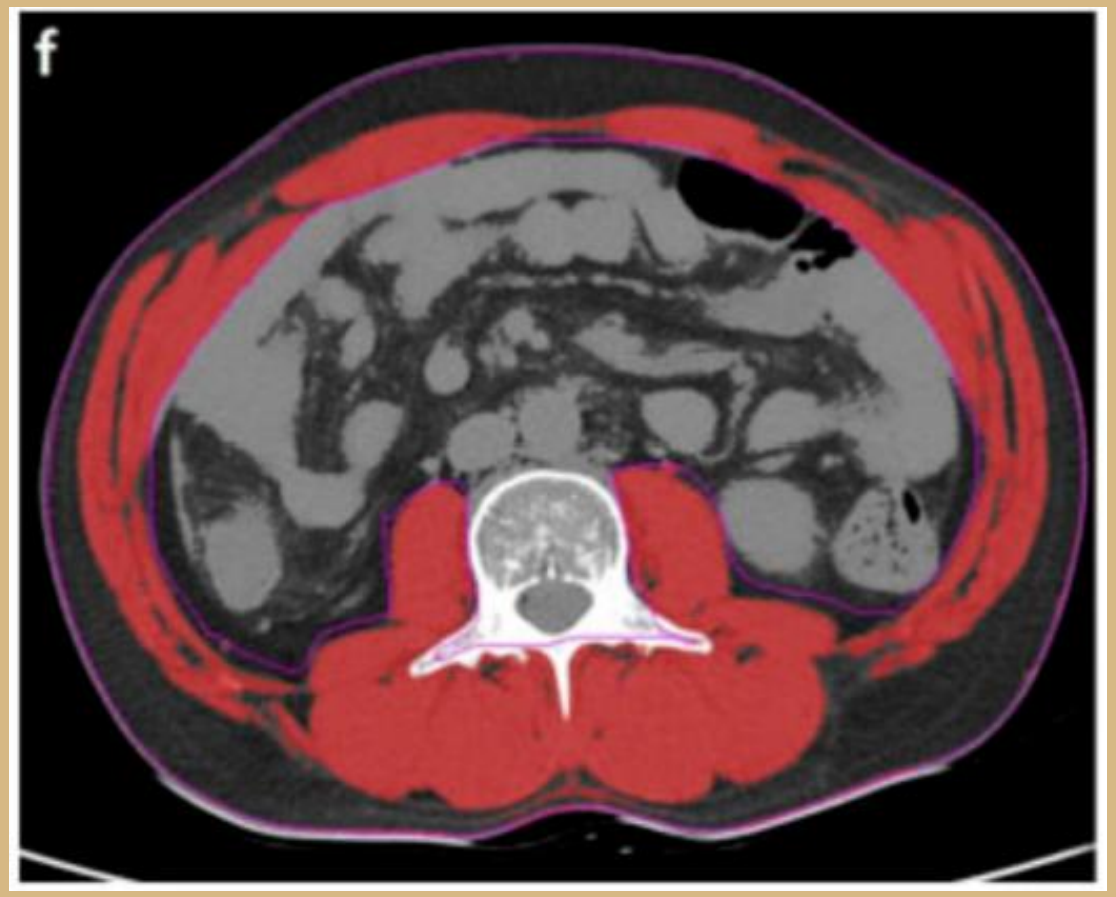
Characteristic	Acute illness– or injury-related malnutrition	Chronic disease–related malnutrition
Weight loss	>2% in 1 week, >5% in 1 month, or >7.5% in 3 months	>5% in 1 month, >7.5% in 3 months, >10% in 6 months, or >20% in 1 year
Energy intake	≤50% for ≥5 days	≤75% for ≥1 month
Body fat	Moderate depletion	Severe depletion
Muscle mass	Moderate depletion	Severe depletion
Fluid accumulation	Moderate-to-severe	Severe
Grip strength	Not recommended in the intensive care unit	Reduced for age/gender

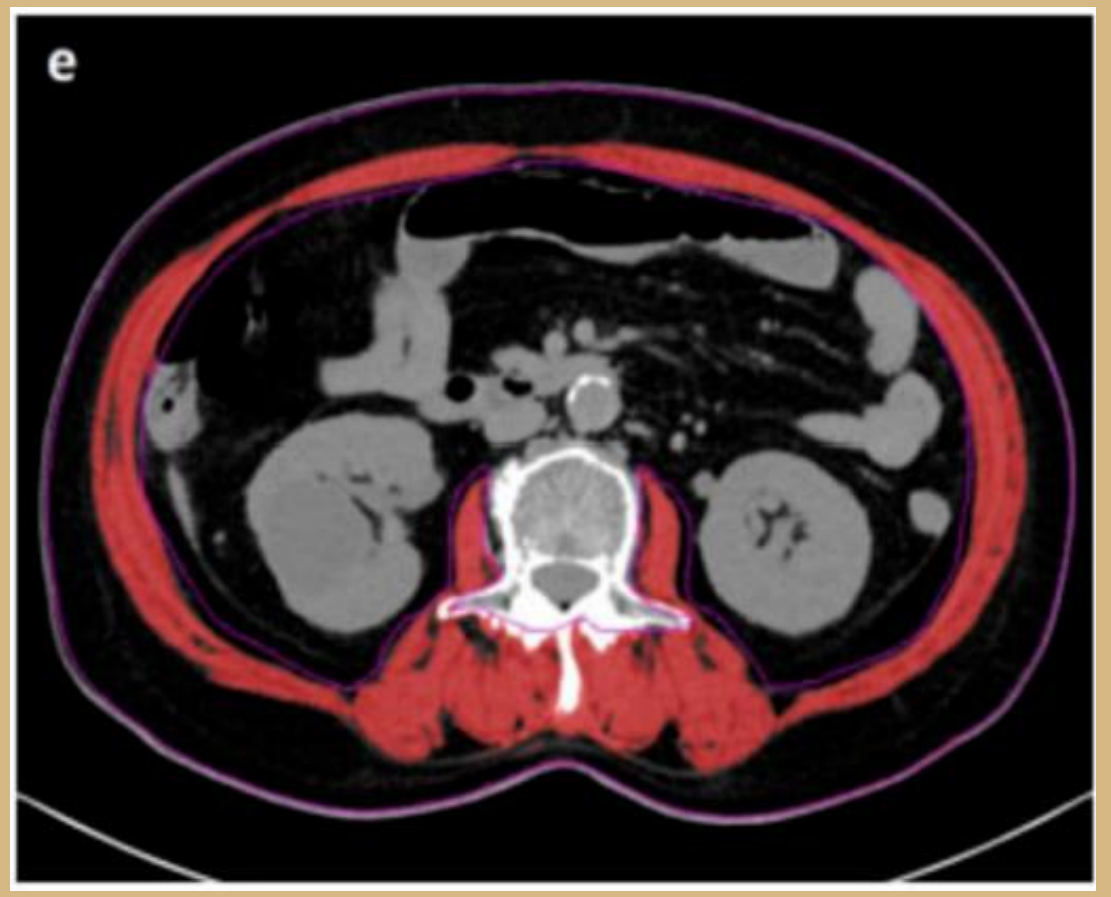
Sarcopenia

- Strength recovers faster than mass
- Strength Assessments
  - Handgrip Strength
  - 6 Minute Walk
  - Daily Step Count
  - Sit-to-Stand

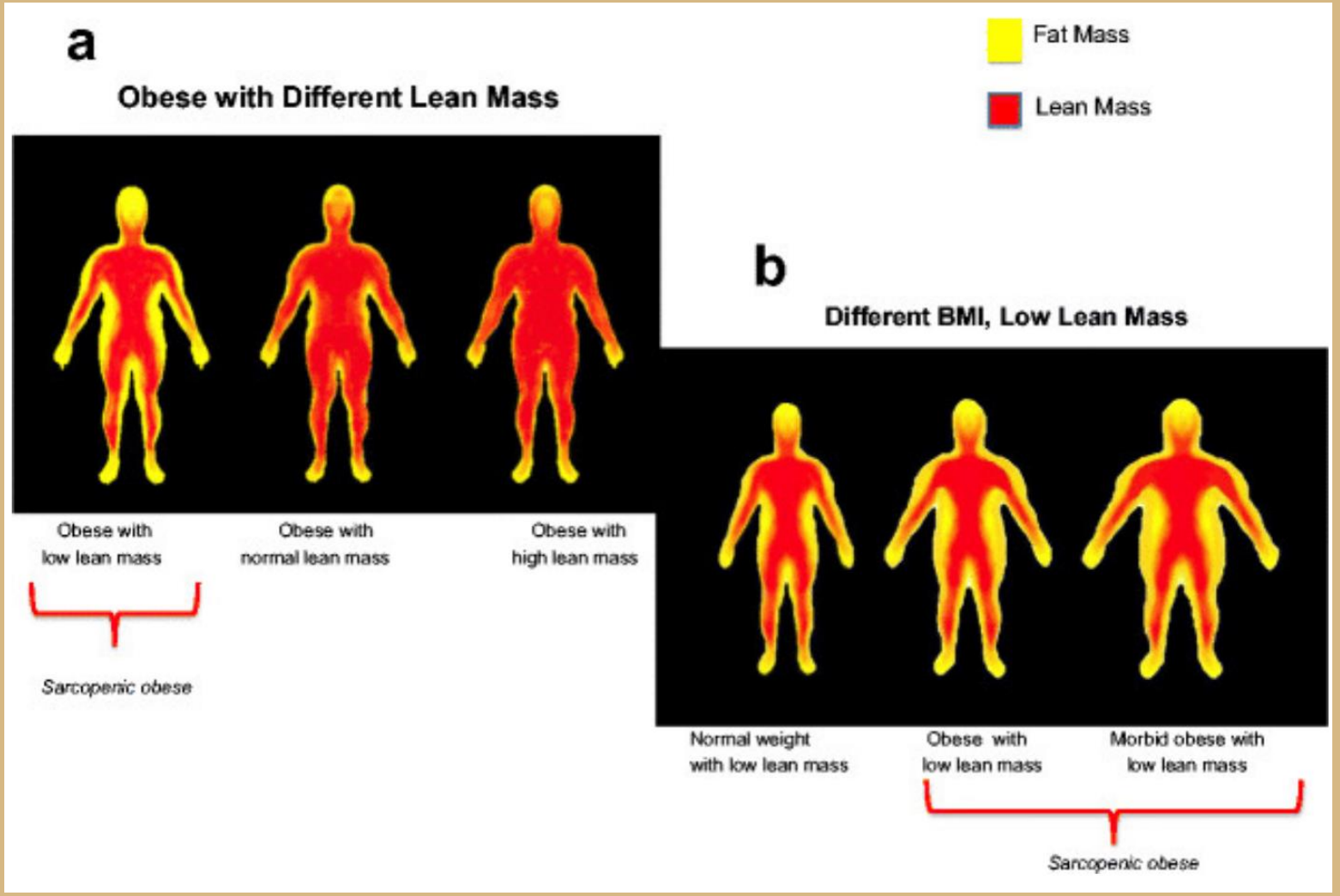


Sarcopenia





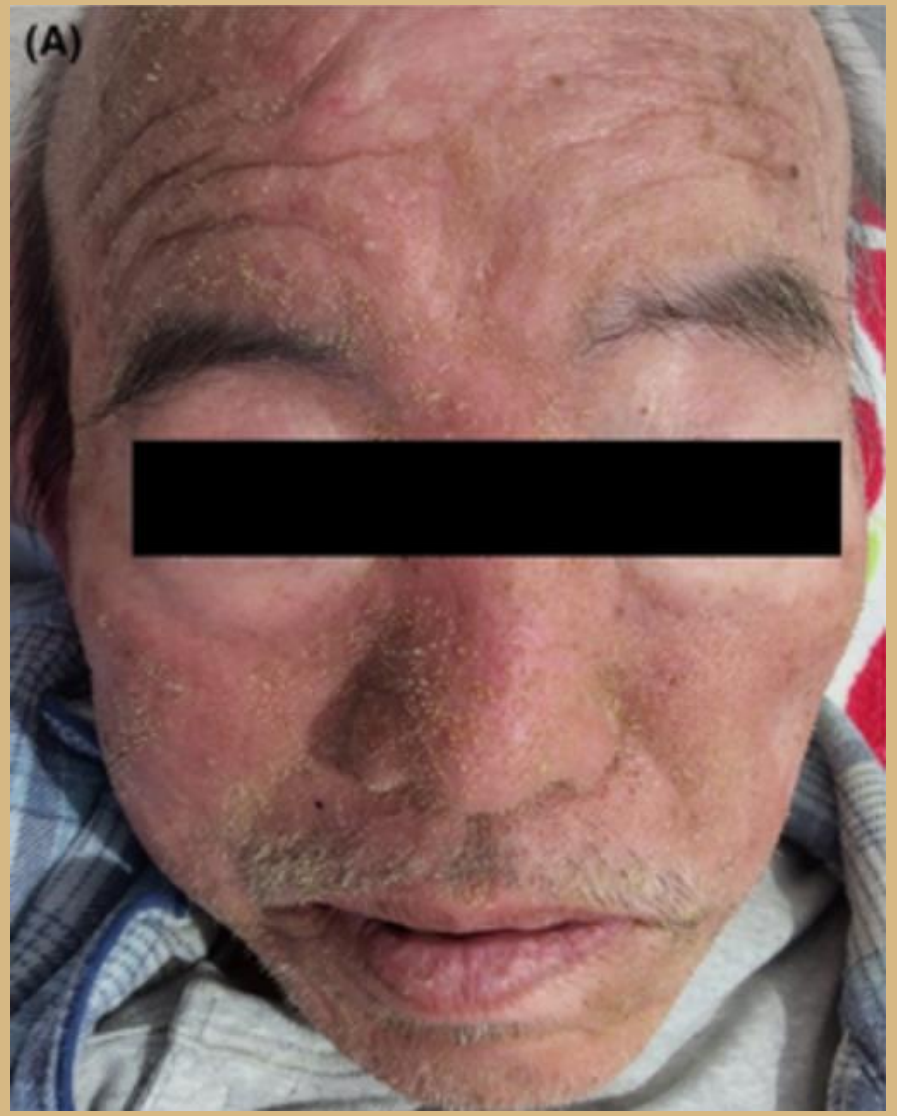
Sarcopenic Obesity

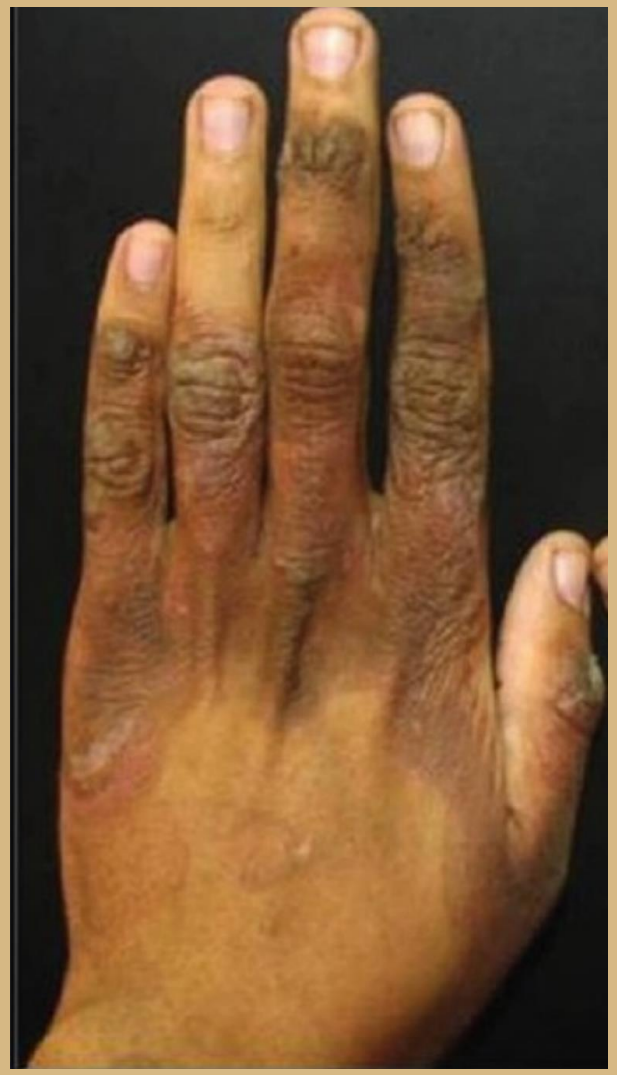


Hypozincemia

“The lesions were similar to seborrheic dermatitis, and they occurred in areas of high sebaceous gland concentration. Hyperkeratotic lesions were also seen on the extensor surfaces of large joints.”

Hypozincemia





Hypozincemia

- Depressed mental function
- Impaired night vision
- Anorexia
- Alterations in taste/smell
- Hypogonadism
- Depressed wound healing
- Altered immune function

Other Nutritional Recommendations

- Protein 1.2-1.5 g/kg/d + DEFINITELY NO RESTRICTIONS
  - Recommending vegetarian sources if possible
- L-Ornithine L-Aspartate and/or Branch chain amino acids supplement in those who can't meet the protein needs or have HE**
- Late night snacks good**
- Coffee is good? (2+ cups a day, even decaf)
- MASH w/o cirrhosis -> Vitamin E
- Treat Vitamin D insufficiency/deficiency
  - Lower levels w/ higher MELD/CTP + assoc'd w/ worse mortality
  - Might help reduce falls/fractures
- L-carnitine if muscle cramps
- Thiamine/Folate

Sodium/Water

- Edema/Ascites + Na < 126
  - May need water restriction

- ?Na restriction: is the benefit of sodium restriction worth the risk of inadequate nutritional intake???
  - No recommendations for or against sodium restriction on diuretics

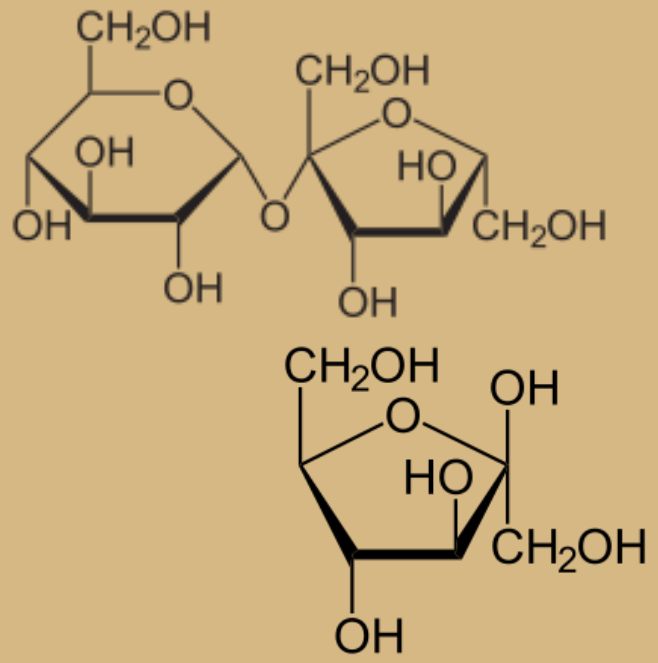
$$\frac{\textbf{Sodium}}{\textbf{Potassium}}$$

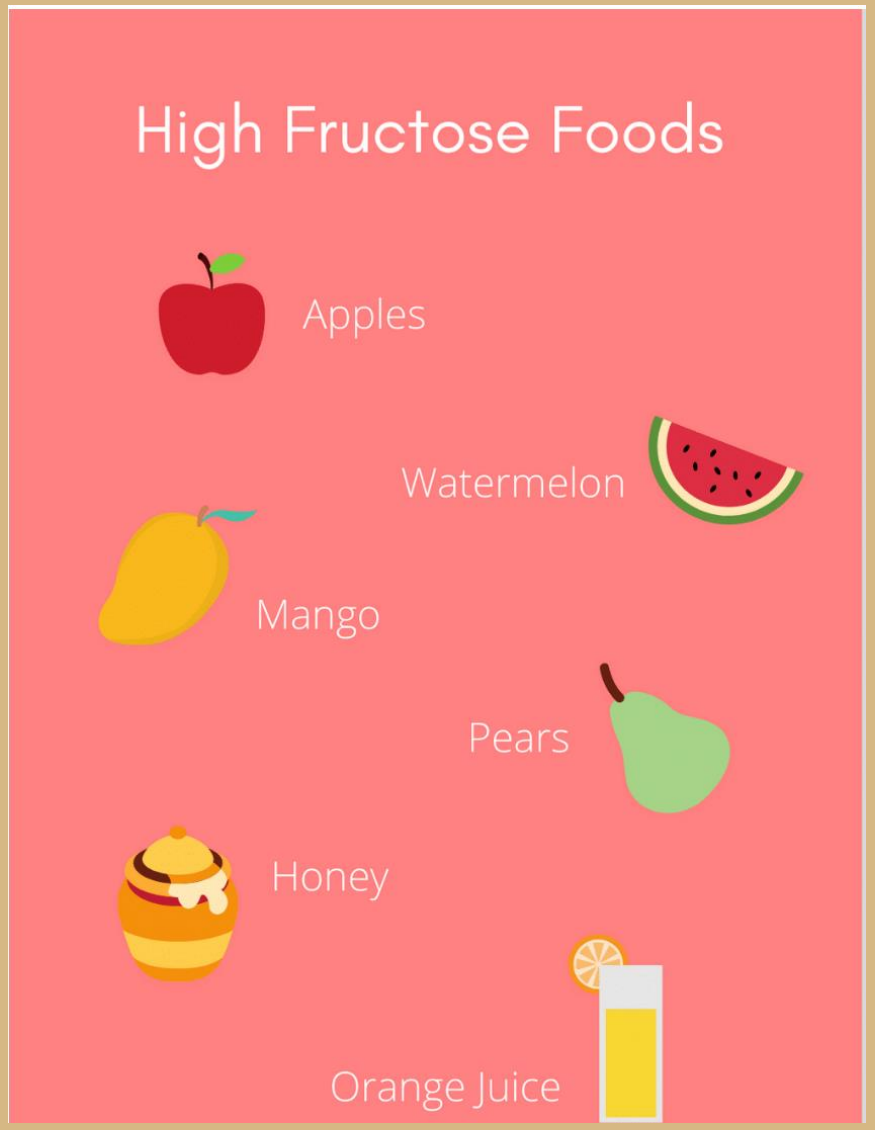
> 1 **Expect volume loss**

< 1 **Need higher diuretic dose**

Fructose/Sucrose

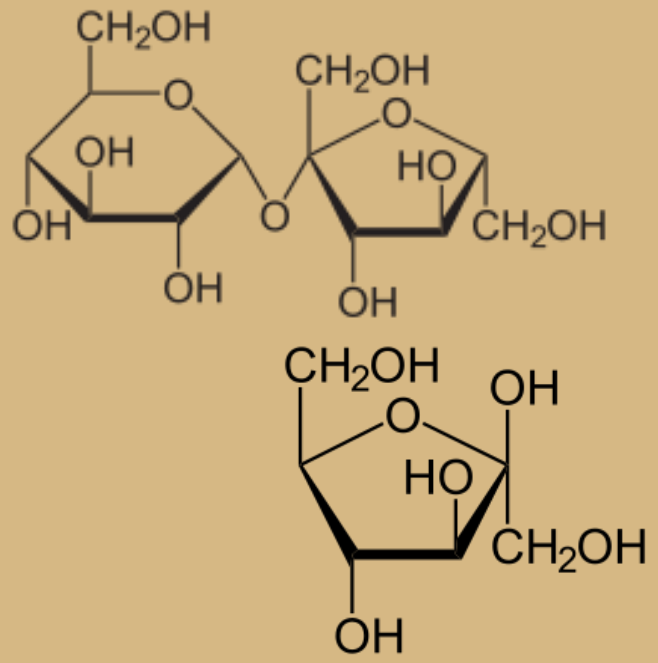
- Avoid high-fructose diets as this exacerbates MASLD





Fructose/Sucrose

- Avoid high-fructose diets as this exacerbates MASLD



Perioperative Care

ACG and EASL – Fall 2025

- 48yoF with decompensated alcoholic cirrhosis admitted from transplant clinic due to rising bilirubin, increased abdominal distension, and encephalopathy. Paracentesis performed in the ER pulled 2L and was negative for SBP. She has a reducible umbilical hernia.
- Day 3: Oral lactulose has been quite effective, and she is back to baseline mentation. Labs are all stable/improved. You're discussing discharge plans.
- Patient woke up from a nap with constant, moderate-severe lower abdominal pain. Her hernia is no longer reducible.

To Cut or Not to Cut

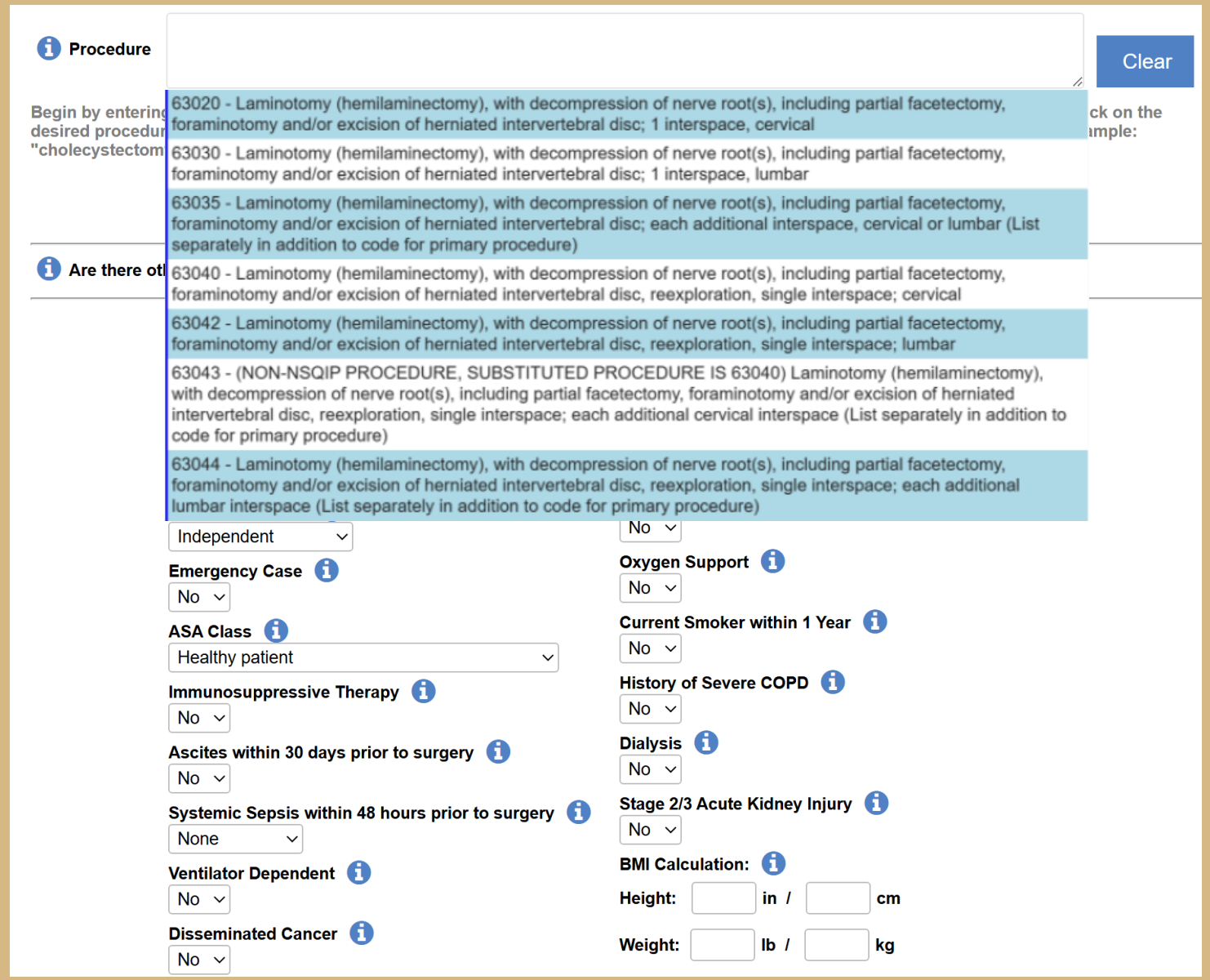
- Sodium 132
- Creatinine 1.2
- Albumin 3.1
- T. Bili 4.1
- INR 1.9

- Alcoholic liver disease
  - Moderate Ascites
  - No encephalopathy
- Platelets 170
- BMI 31

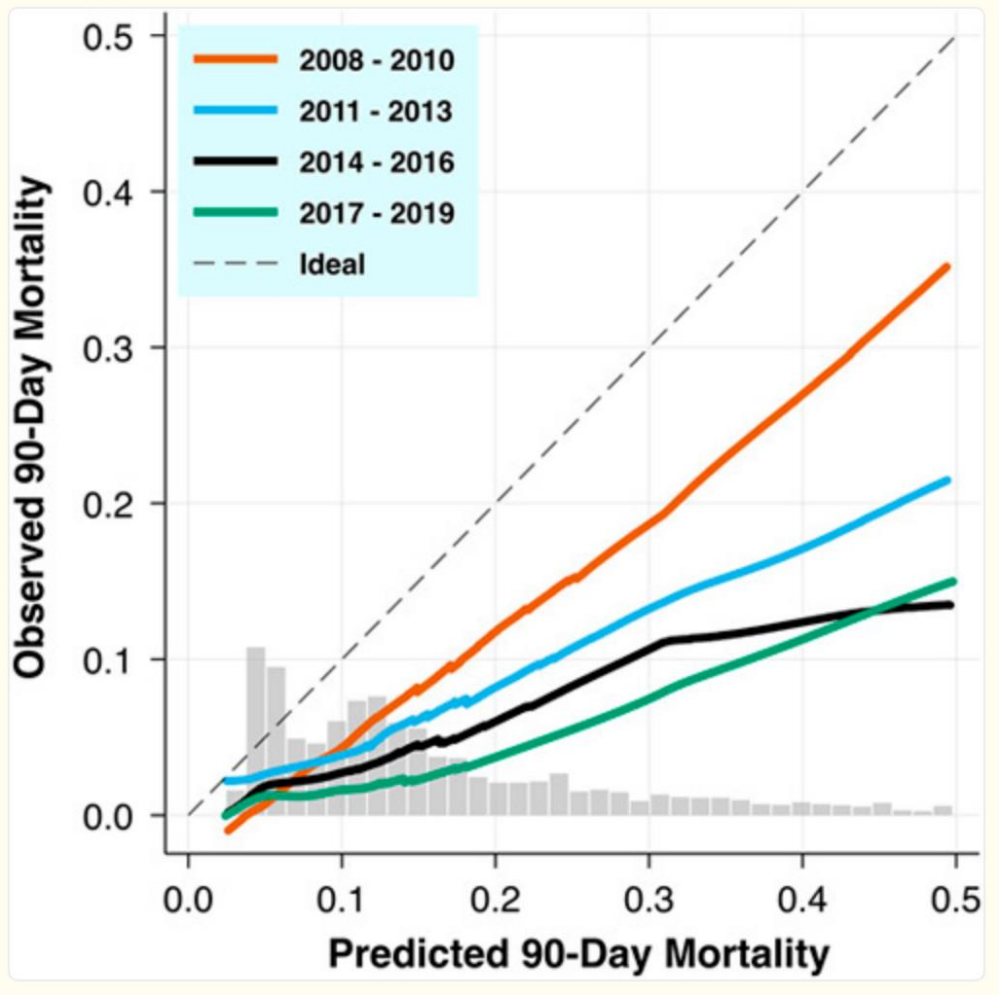
To Cut or Not to Cut

- Child-Pugh C
  - 1-3 year life expectancy.
  - 82% perioperative mortality for abdominal surgery
- MELD-Na
  - 25: 14-15% 90d mortality
- MELD 3.0
  - 25: 87.7% 90d survival -> 12.3% mortality

Risk Stratification



Risk Stratification



What is the age?

What is the ASA score?

Enter 3 for compensated cirrhosis
Enter 4 for decompensated cirrhosis

What is the bilirubin? (mg/dl)

What is the creatinine? (mg/dl)

What is the INR?

What is the etiology of cirrhosis?

- ○ Alcoholic or Cholestatic
- ○ Viral/Other

VOCAL PENN Calculator

Penn Website

MD Calc

VOCAL PENN

- Age, median (IQR)
- Male sex
- Race
  - White
  - Black
  - Hispanic
  - Asian
  - Other
- Smoking history
  - Never smoker
  - Former smoker
  - Current smoker
- Hazardous alcohol use

- Surgery category
  - Abdominal—laparoscopic
  - Abdominal—open
  - Abdominal wall
  - Vascular
  - Major orthopedic
  - Chest/cardiac
- Emergency surgery
- ASA classification (ordinal)
  - 2
  - 3
  - 4
- ASA reclassified (binary)*
  - 3
  - 4

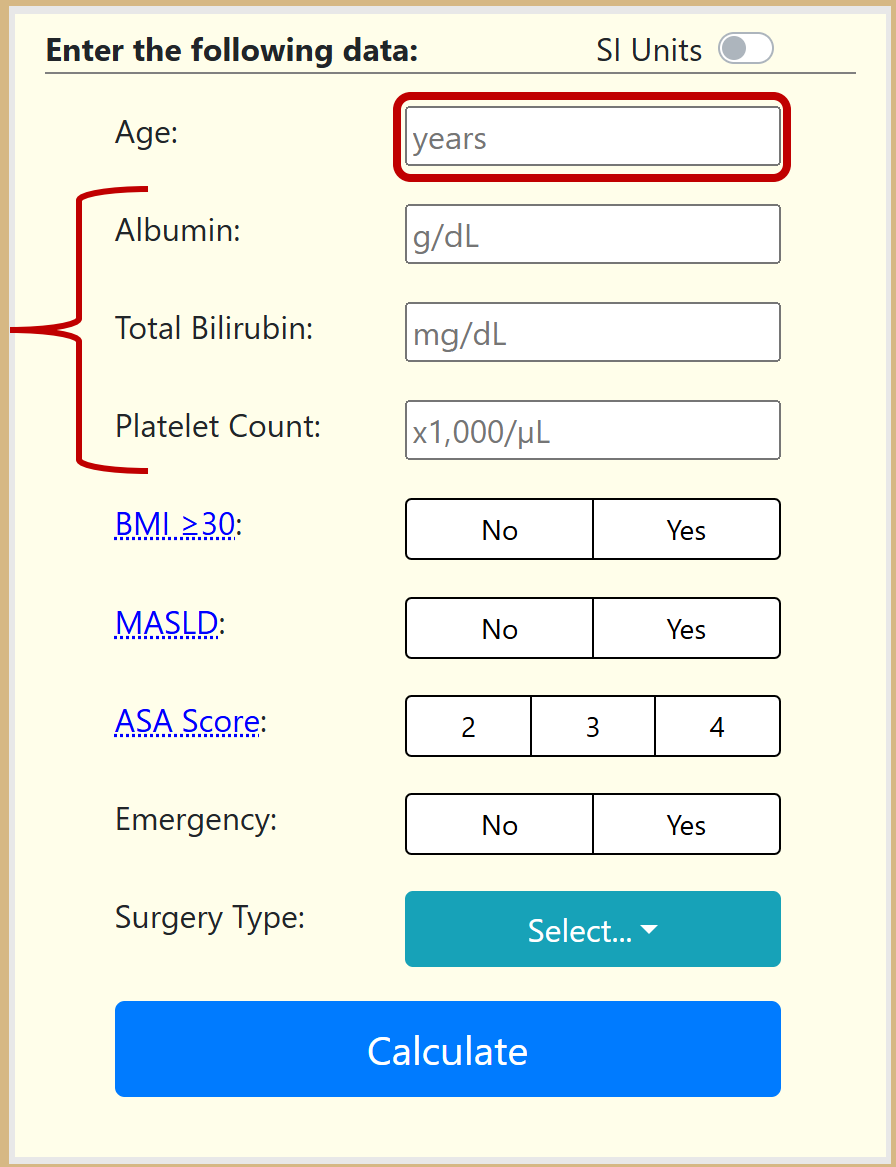
- Sodium, median (IQR)
- Creatinine, median (IQR)
- AST, median (IQR)
- ALT, median (IQR)
- Total bilirubin, median (IQR)
- Albumin, median (IQR)
- Platelet count, median (IQR)
- INR, median (IQR)
- MELD, median (IQR)
- MELD-Na, median (IQR)
- CTP class
  - A
  - B
  - C

- Ascites category
  - None
  - Slight
  - Moderate
- HE
  - No encephalopathy
  - Grade 1-2
  - Grade 3-4

- Etiology of liver disease
  - Hepatitis C
  - Hepatitis B
  - Alcohol
  - Hepatitis C + alcohol
  - Fatty liver disease
  - Other
- History of previous decompensation
- Hypertension
- Diabetes
- Obesity (BMI ≥ 30)
- Atrial fibrillation
- Coronary artery disease
- Congestive heart failure

VOCAL PENN

Variable	Overall (n = 4,712)
Age, median (IQR)	64 (60, 69)
Male sex	4,582 (97.2%)
Race	
White	2,981 (63.3%)
Black	741 (15.7%)
MELD-Na, median (IQR)	10 (8, 14)
CTP class	
A	4,159 (88.3%)
B	530 (11.2%)
C	23 (0.5%)

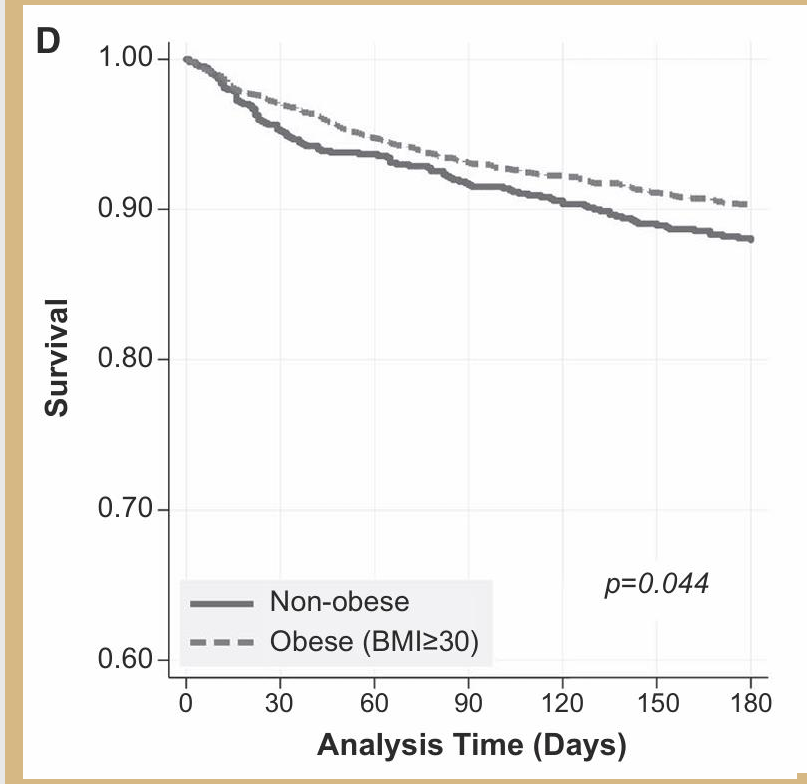


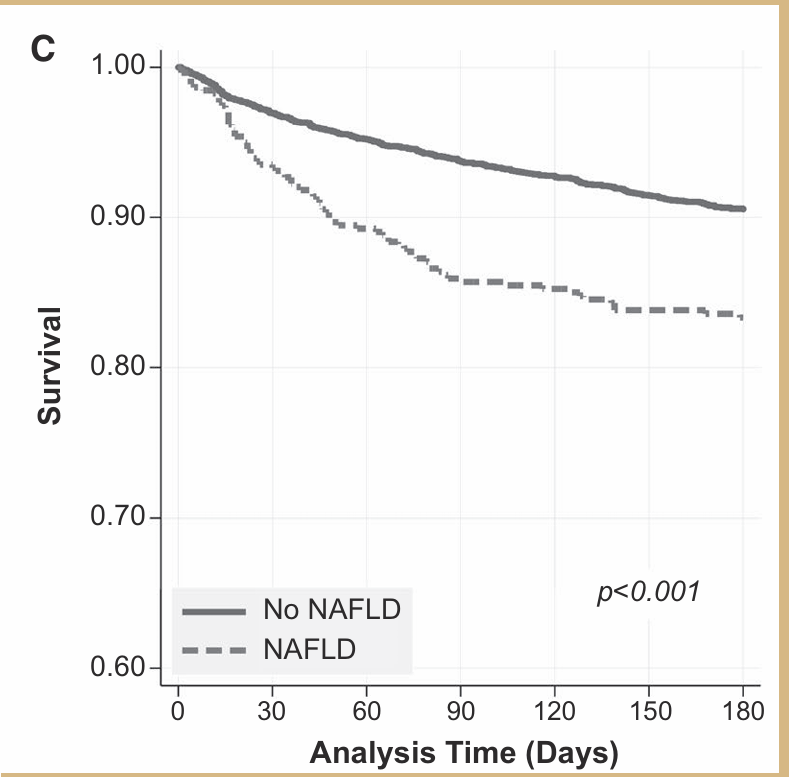
VOCAL PENN

Enter the following data: SI Units

Age:	years
Albumin:	g/dL
Total Bilirubin:	mg/dL
Platelet Count:	x1,000/μL
BMI ≥30:	No / Yes
MASLD:	No / Yes
ASA Score:	2 / 3 / 4
Emergency:	No / Yes
Surgery Type:	Select...

Calculate





VOCAL PENN

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Platelet Count:	x1,000/μL
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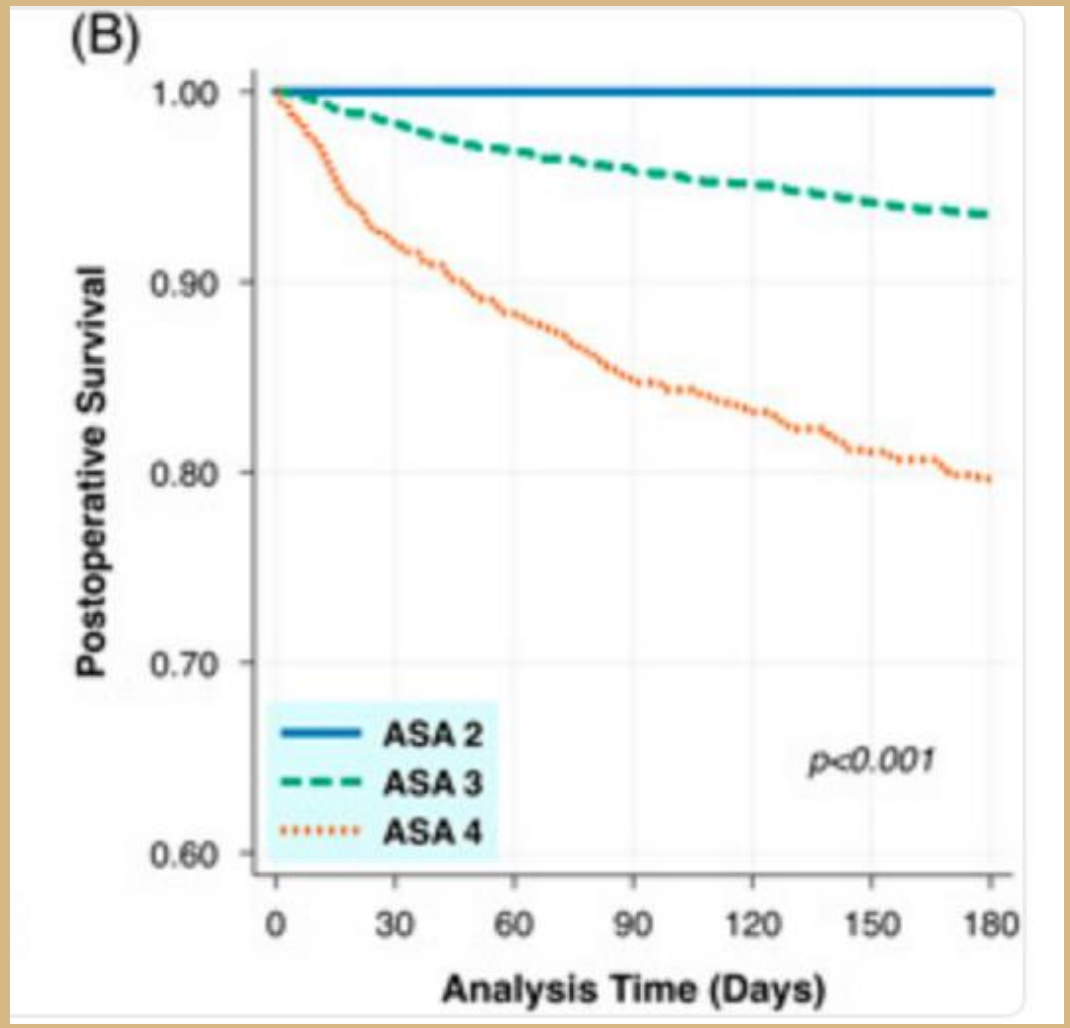
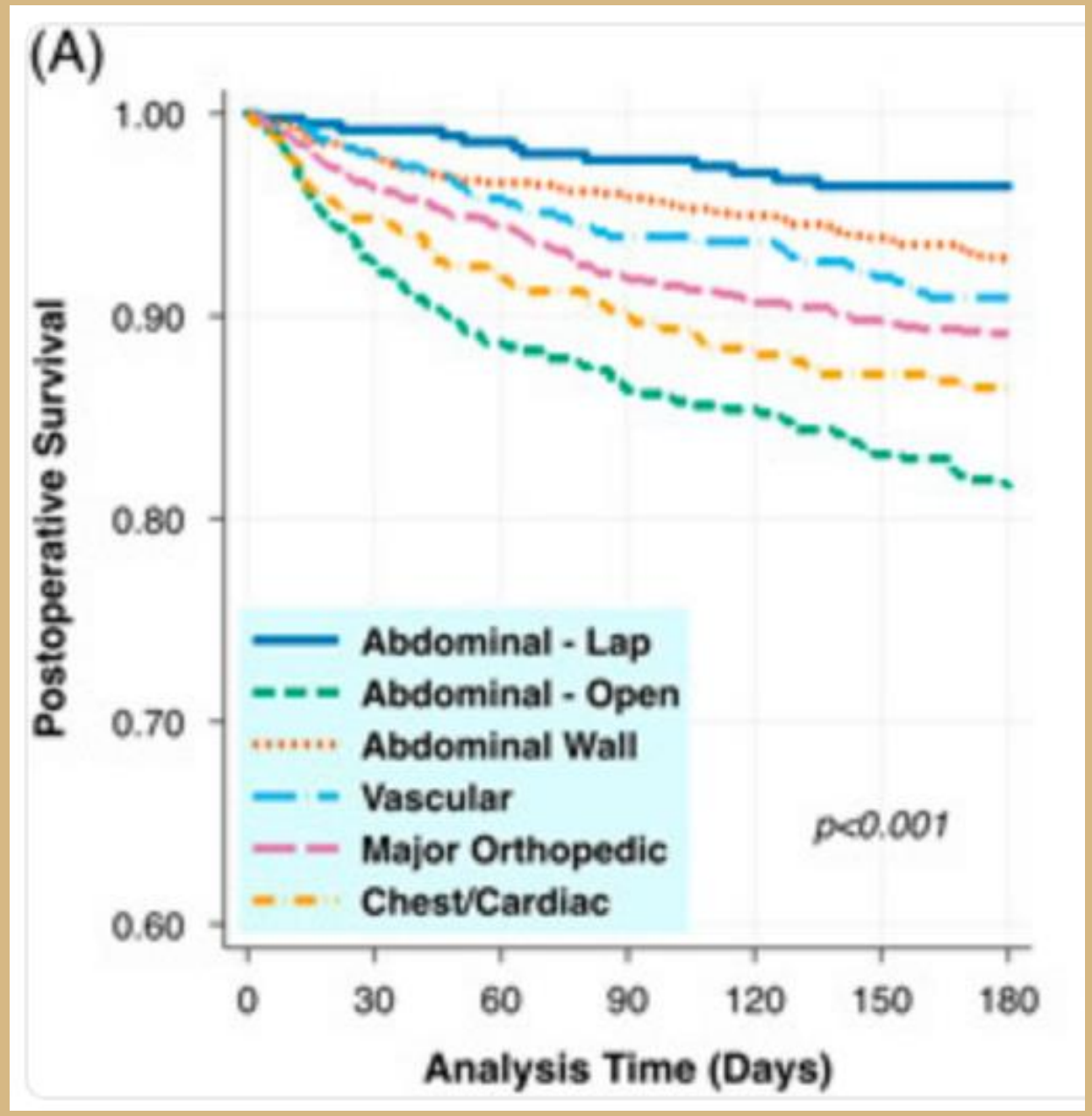
ASA Score:	2 / 3 / 4
Emergency:	No / Yes
Surgery Type:	Select...

Calculate



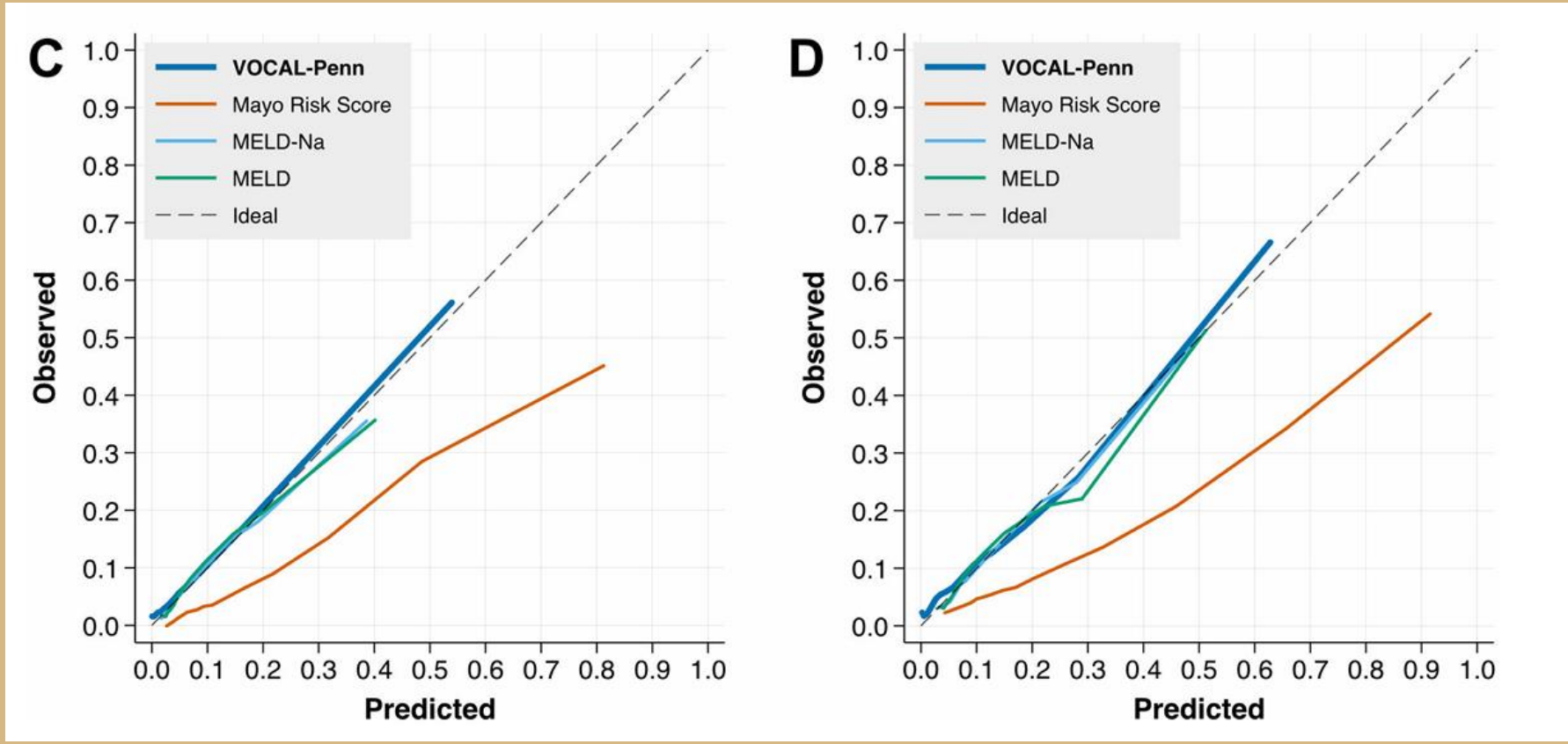
Representative examples of procedures included in different surgery categories:

Category	Examples
Abdominal	Cholecystectomy, exploratory laparotomy, colectomy, laparoscopy for diagnosis or washout, appendectomy, pancreatectomy
Abdominal Wall	Inguinal hernia repair, umbilical hernia repair, incisional/ventral hernia repair
Vascular	Aortic aneurysm repair, bypass graft (femoral-popliteal, femoral-femoral), endovascular aortic repair, thromboendarterectomy (carotid, vertebral, femoral, subclavian)
Major Orthopedic	Total knee arthroplasty, total hip arthroplasty, amputation through femur, amputation through tibia/fibula, open treatment of femoral neck fracture with internal fixation
Chest/Cardiac	Pulmonary lobectomy, thoracoscopy with lobectomy, pleurodesis, wedge resection, aortic valve replacement (with cardiopulmonary bypass), coronary artery bypass graft, mitral valve replacement (with cardiopulmonary bypass)



External Validation

- VOCAL authors using non-VA data (Beth Isreal Deaconess, U. Penn

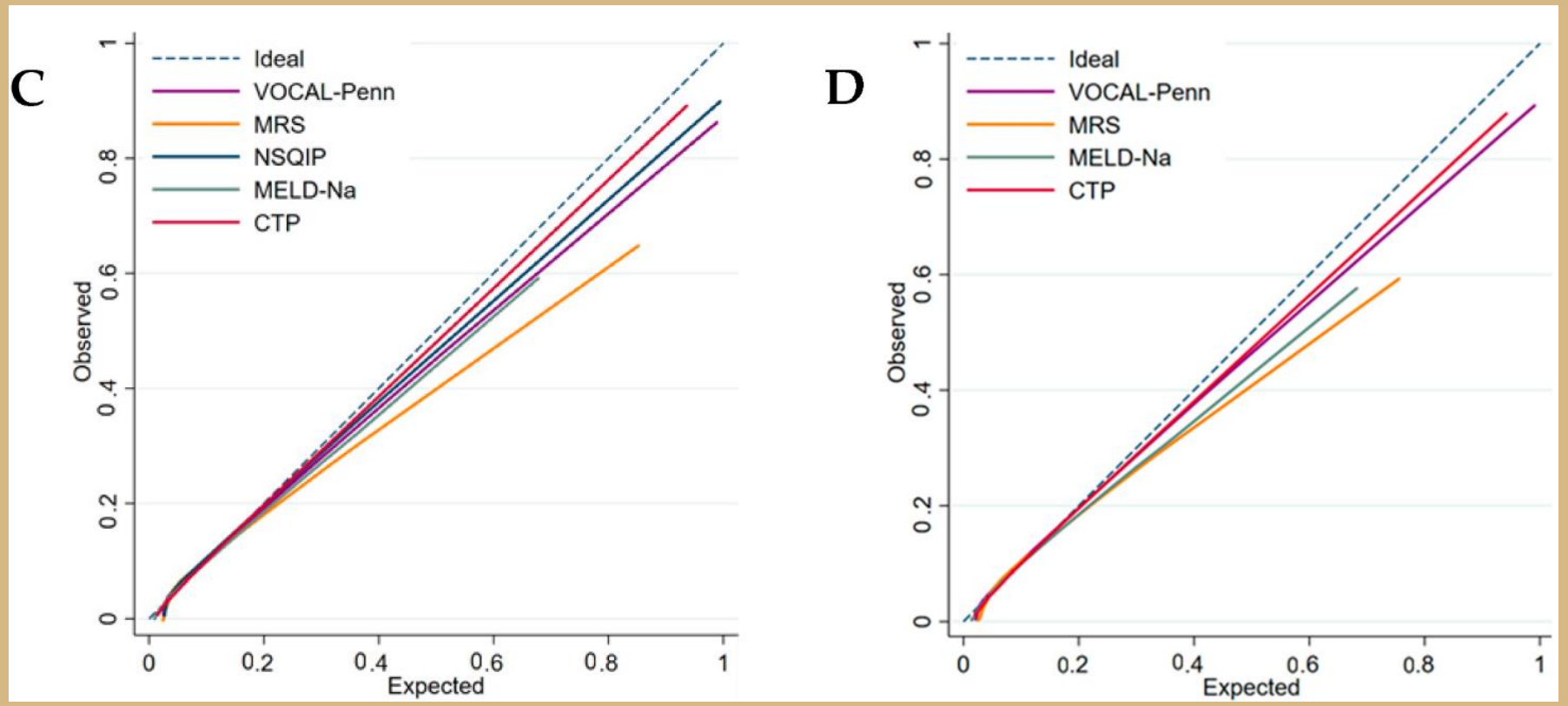


30-d morality

90-d morality

External Validation

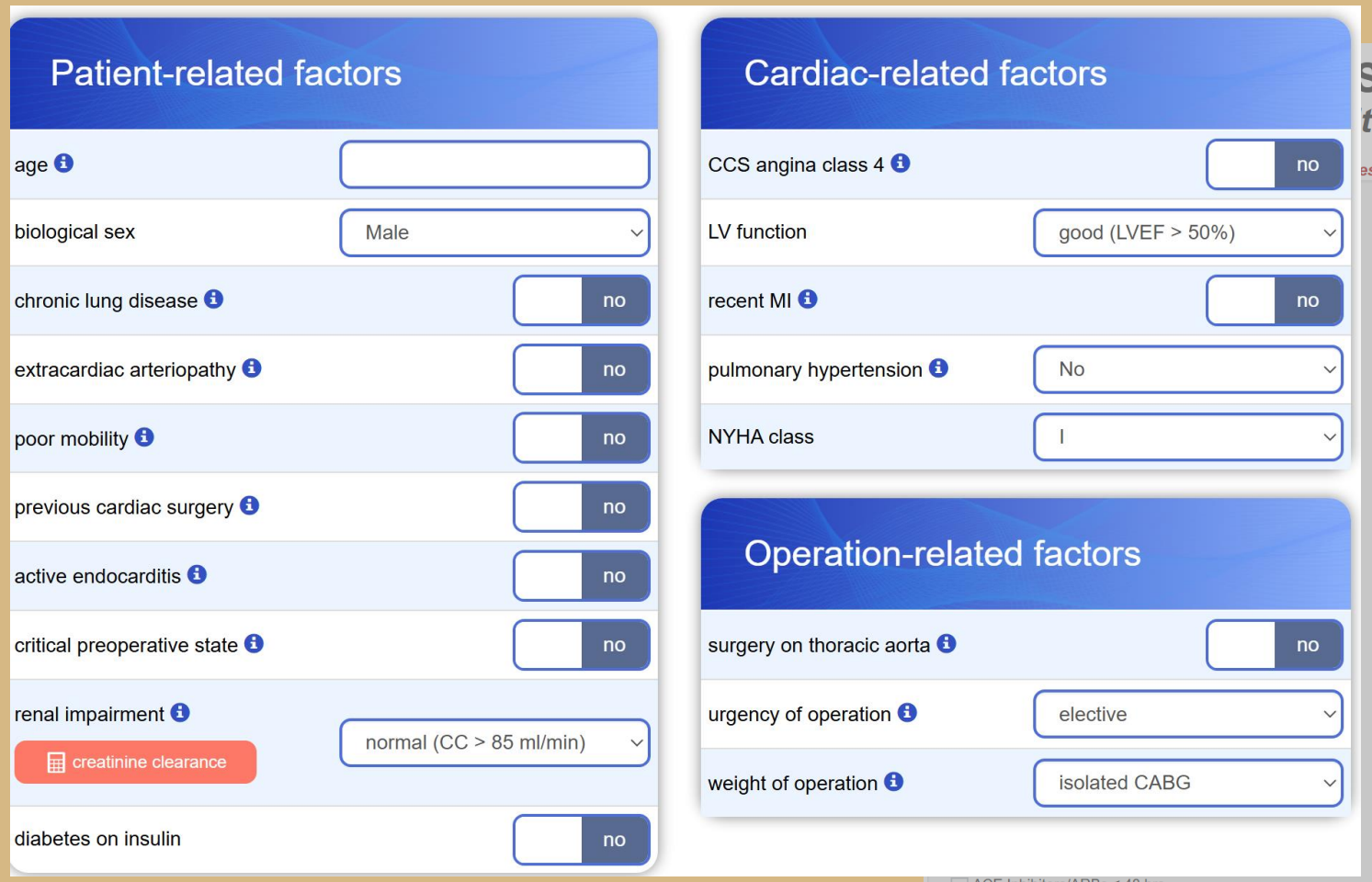
- European study (Barcelona)

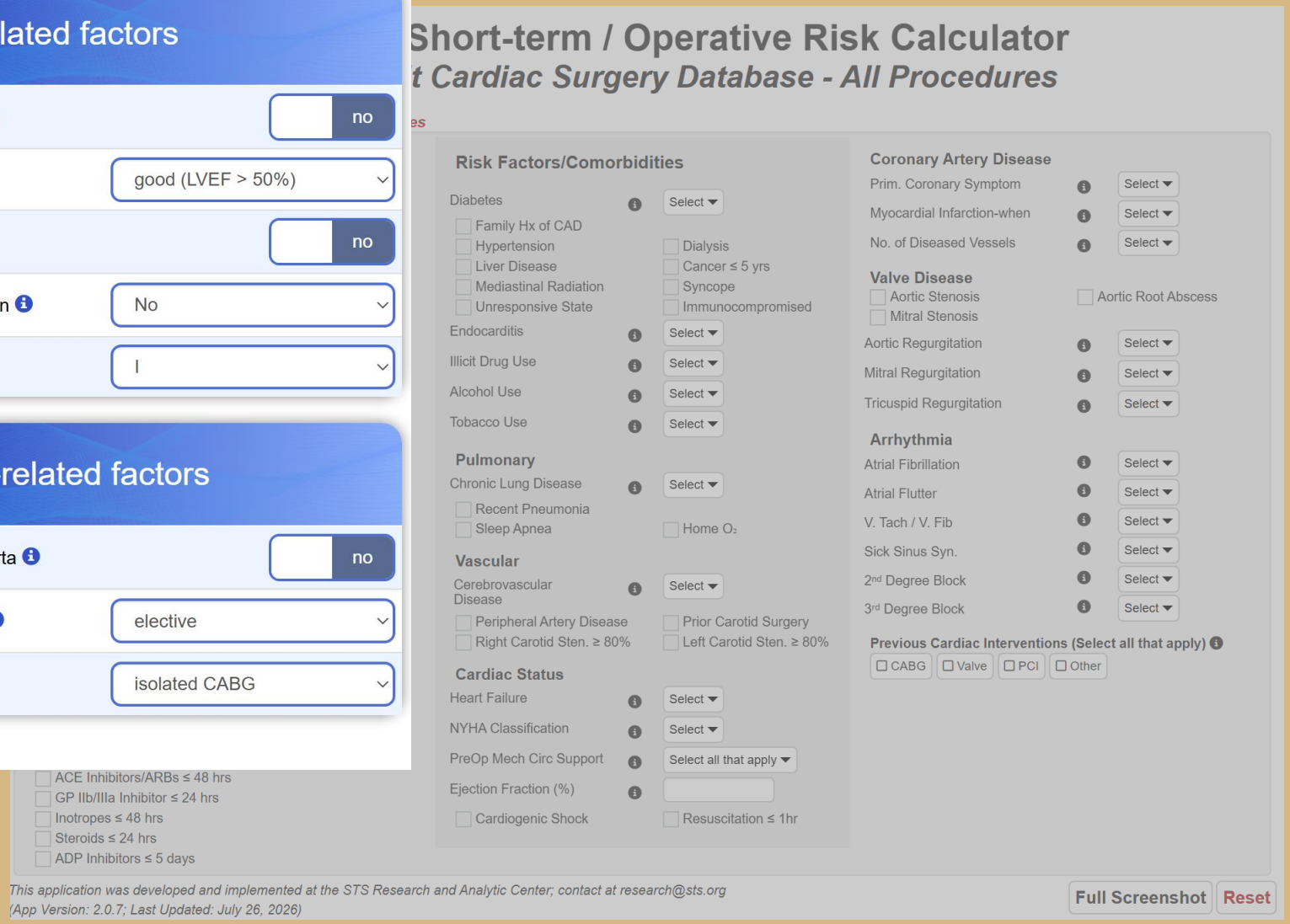


30-d morality

90-d morality

Existing Cardiac Risk Calculators

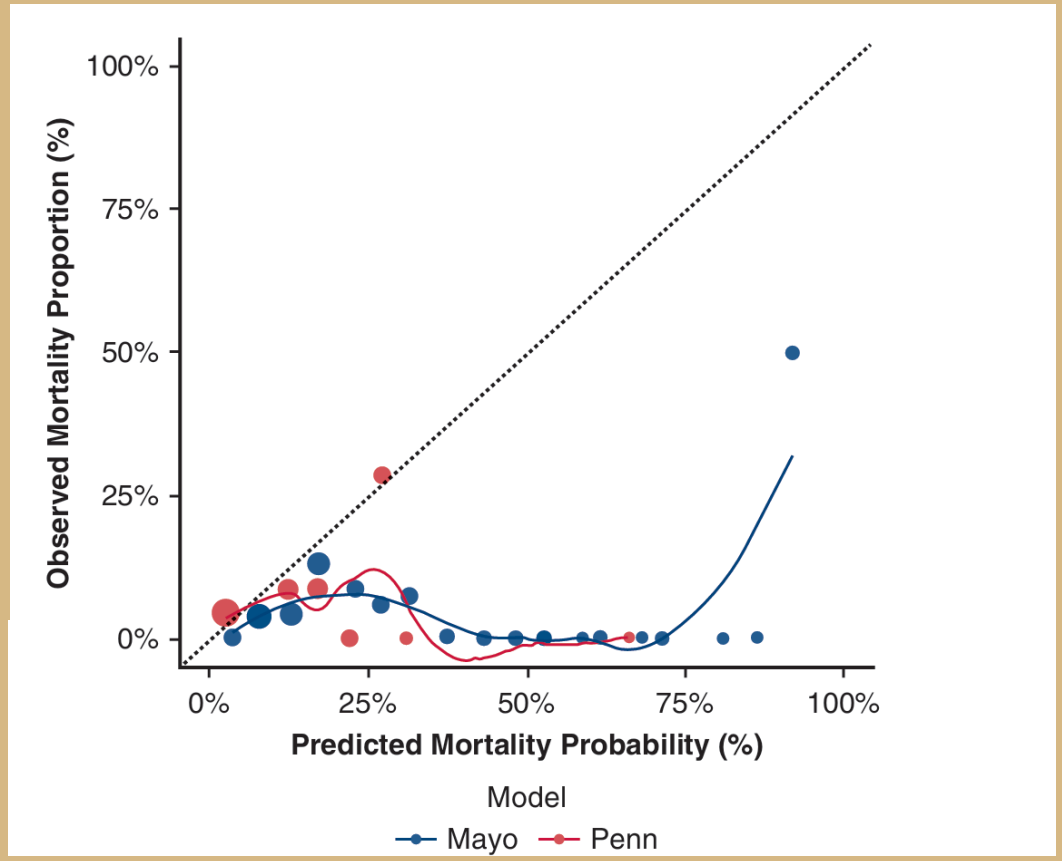




External Validation

- Cleveland Clinic – cardiac-specific

Surgery type, n (%)	
Coronary artery bypass	74 (33.6)
Aortic valve replacement	79 (35.9)
Aortic valve repair	9 (4.1)
Mitral valve replacement	27 (12.3)
Mitral valve repair	46 (20.9)
Tricuspid valve replacement	20 (9.1)
Tricuspid valve repair	67 (30.5)
Aortic root/ascending/arch	36 (16.4)
Maze procedure	34 (15.5)
Pericardiectomy	14 (6.4)



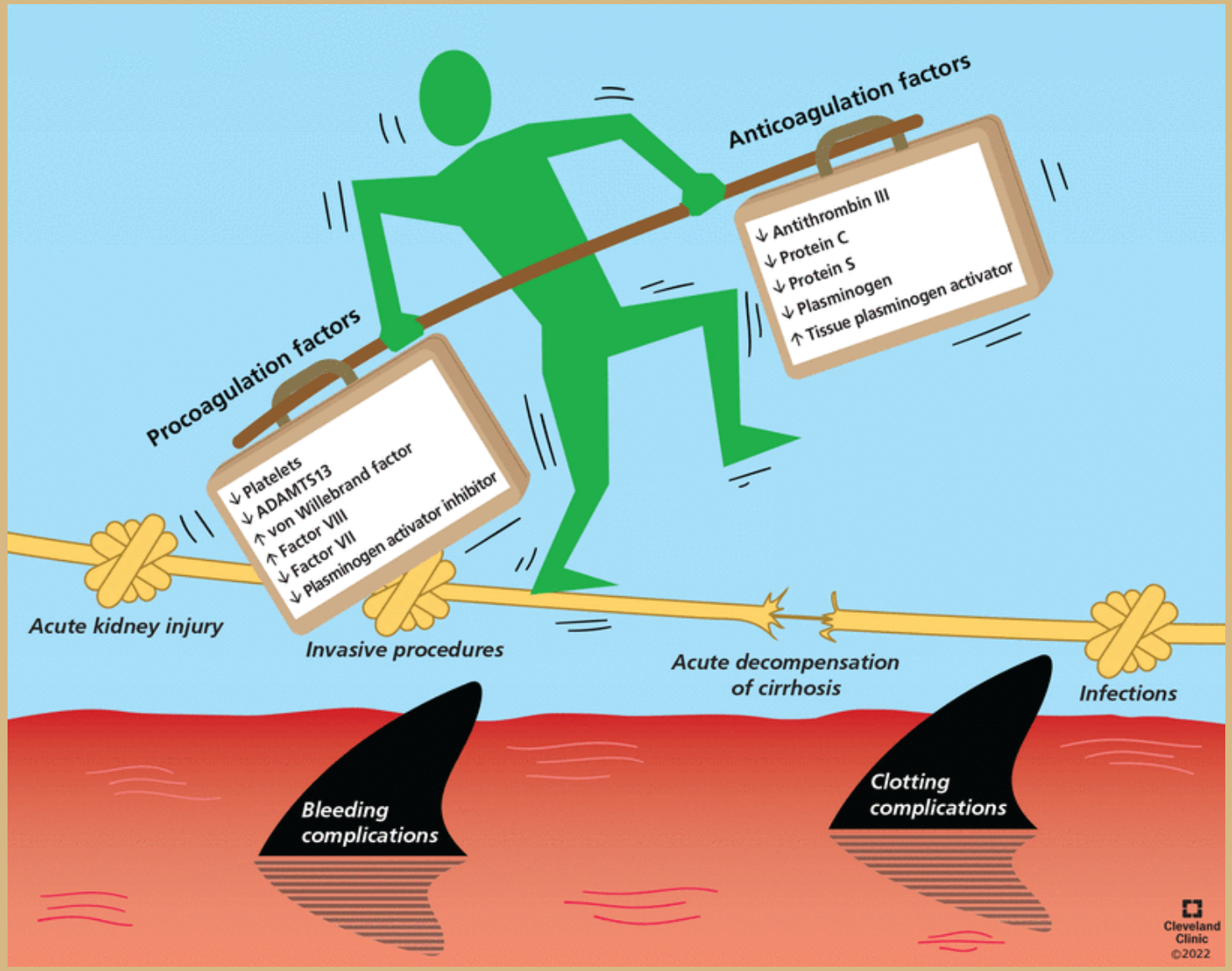
Other Recommendations

- Presence of decompensation and/or sev portal HTN associated w/ worse outcomes

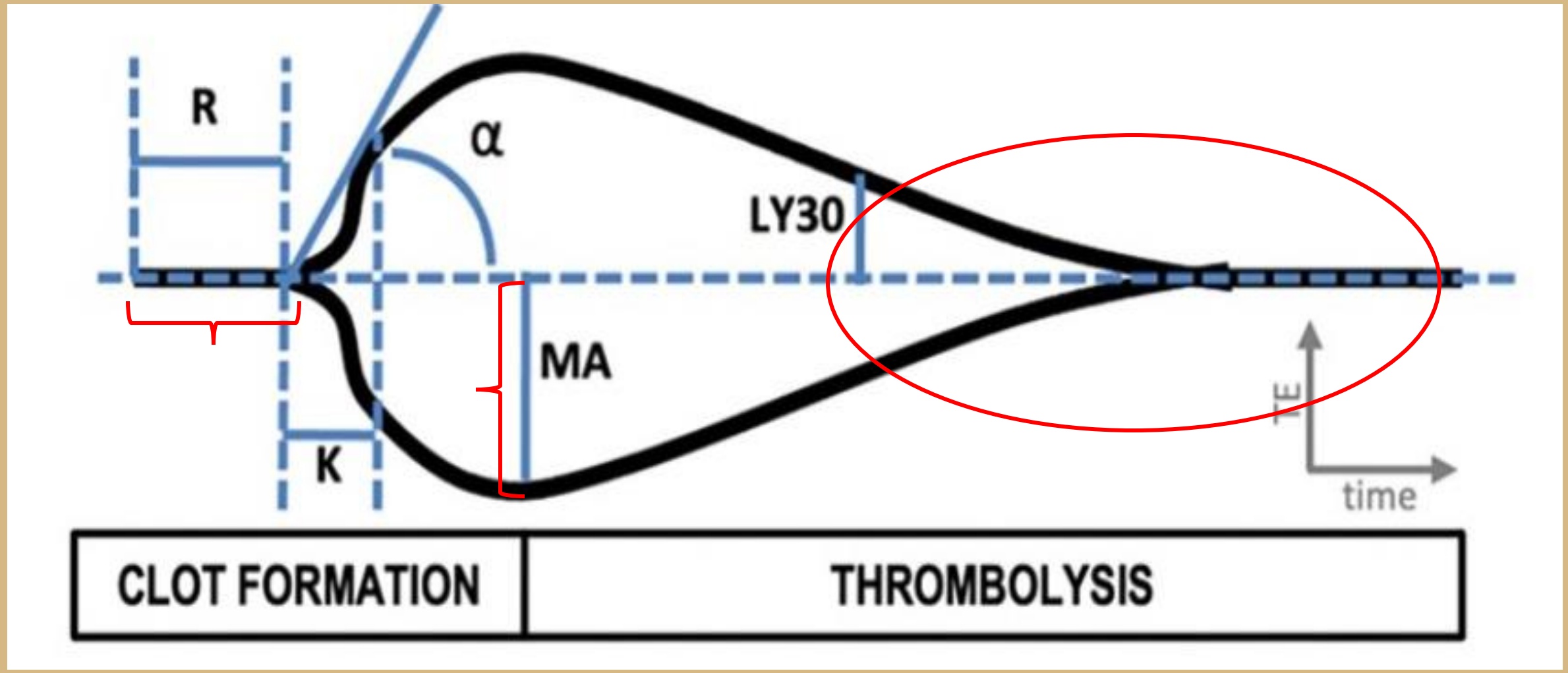
- And a fair amount of energy on elective/planned surgeries… optimize ascites, manage malnutrition/sarcopenia/frailty

Coagulopathy

- Bleeding risk rises as plt fall below 50-75.
- Vit K and blood products to change INR not helpful.
- TEG if you can.



Thromboelastography



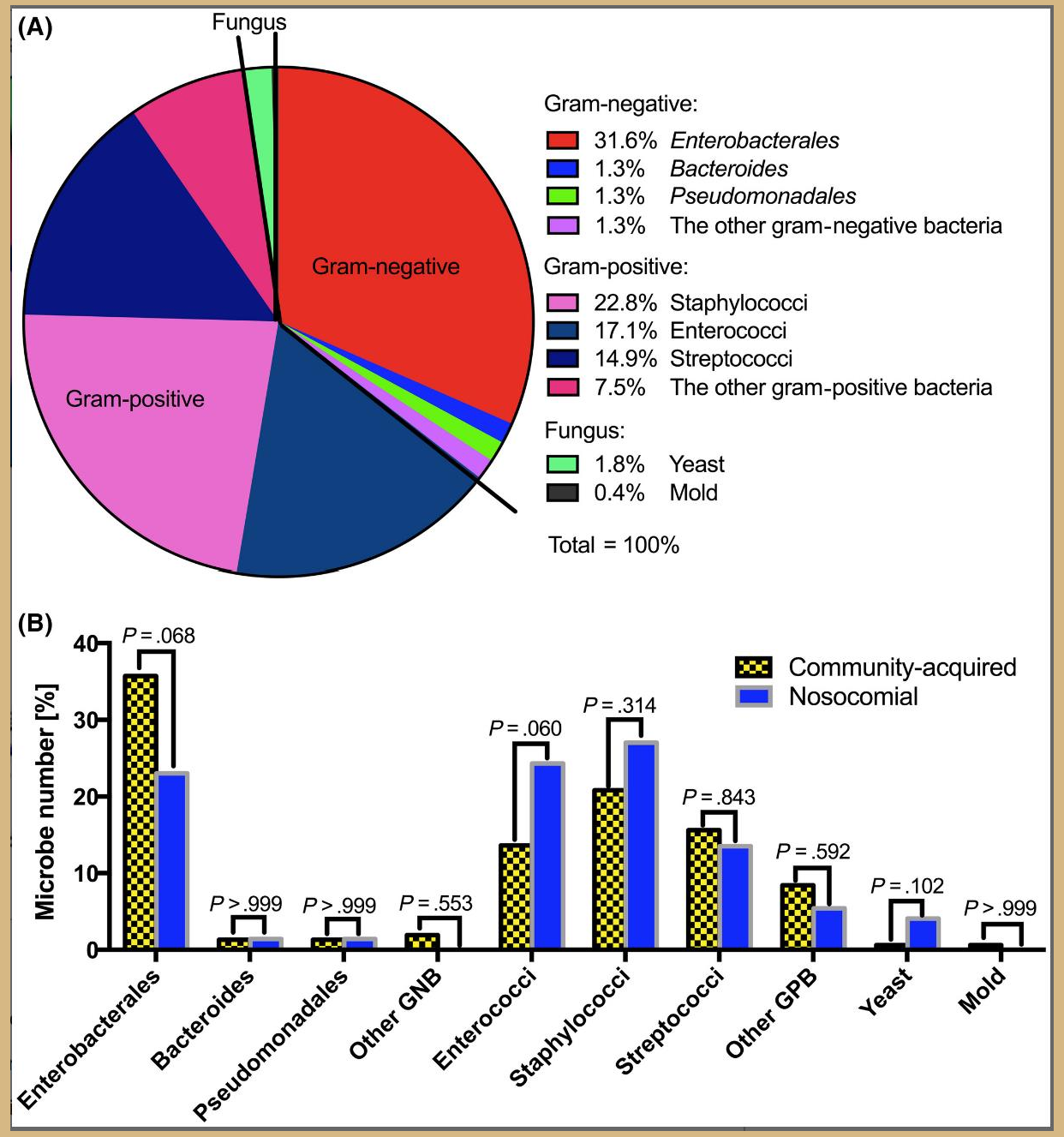
Upcoming Guidelines

- ACG: AKI in Cirrhosis
- ACG: MASH
- ACG: Preventive Care in Cirrhosis Patients
- ACG: Portal Hypertensive Bleeding

SBP Prophylaxis

Current Guidelines

- Prior Episode of SBP
- During portal hypertensive bleed
- Ascites Total Protein < 1.5
  - + Renal dysfunction
    - Cr > 1.2/BUN > 25
    - Na < 130
  - + Hepatic dysfunction
    - Bili > 3
    - Child-Pugh C
- During other admission*

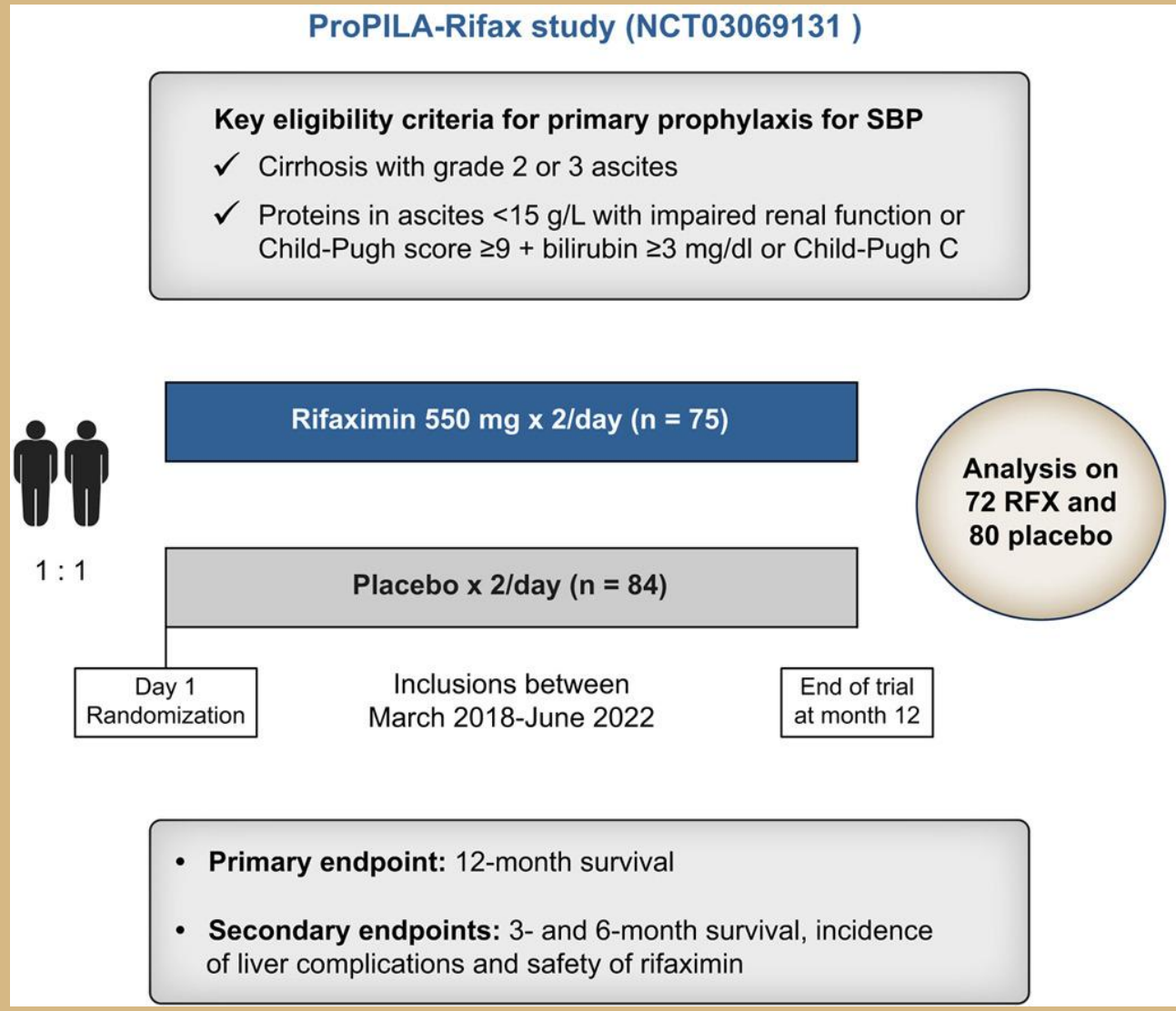


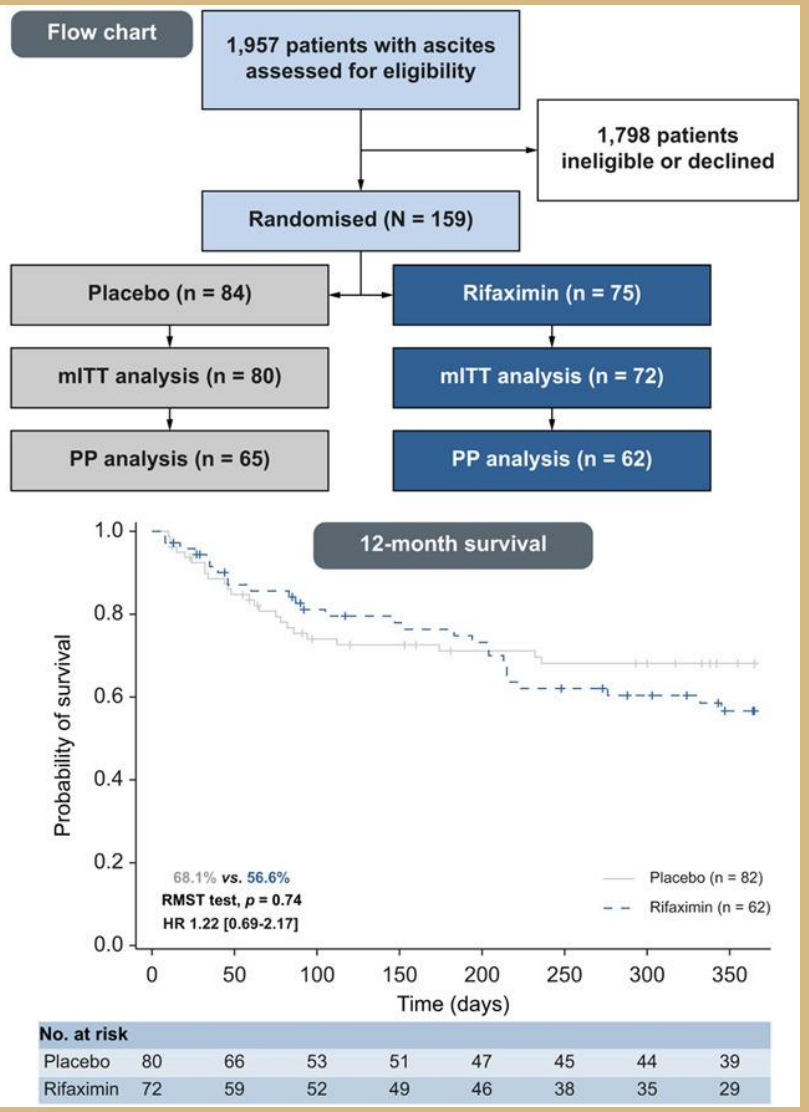
Primary Prophylaxis

Badal et al, 2023

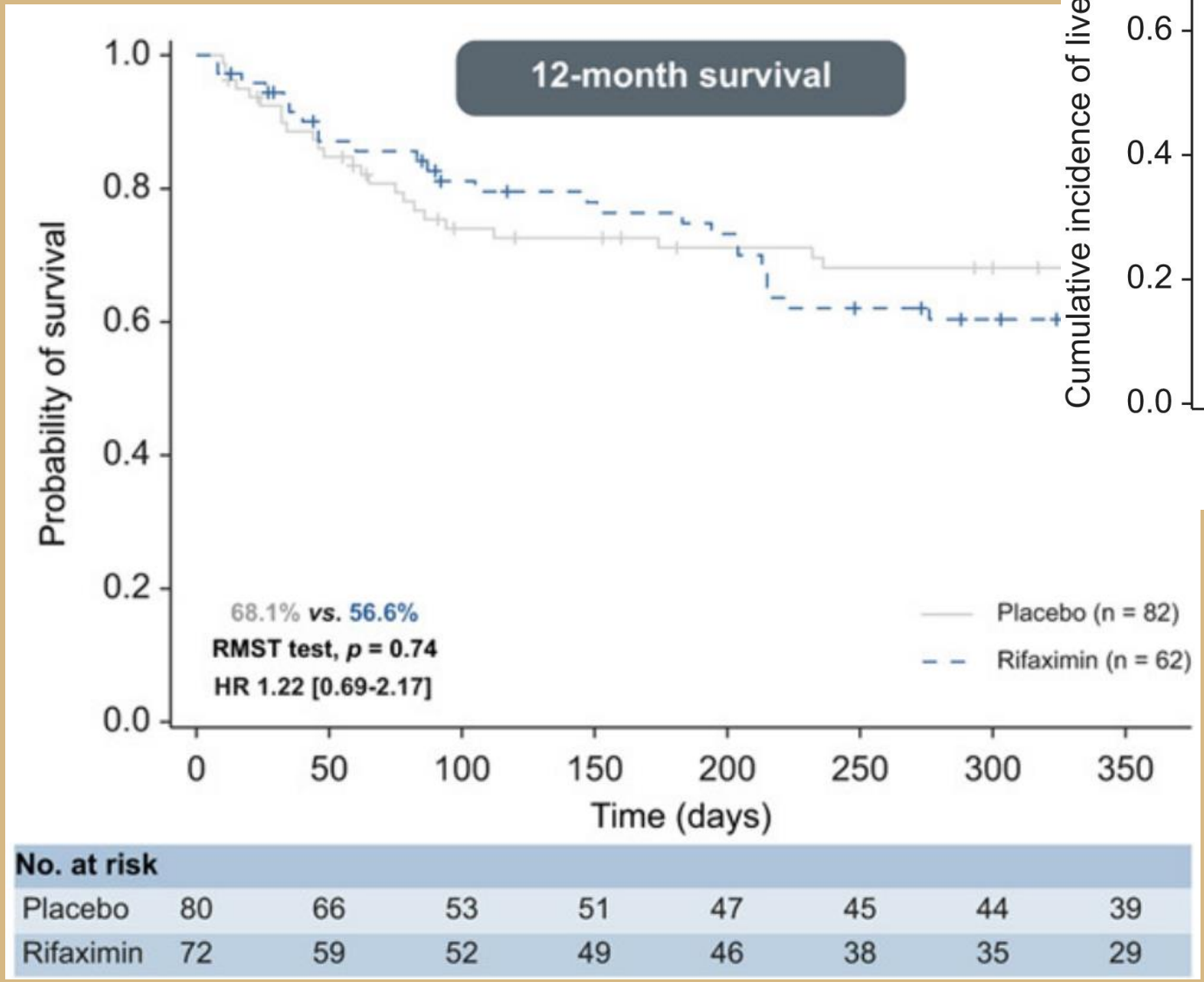
	On primary prophylaxis (n=1367), n (%)	Not on primary prophylaxis (n=6192), n (%)	*p*
Age	62.1±8.6	62.7±9.0	**0.02**
Sex (M)	1300 (97.1)	5894 (97.7)	0.26
MELD-Na on admission	15.8±8.9	15.9±9.0	0.80
LOS (d)	13.6±9.0	11.8±8.4	**<0.0001**
Second SBP	12 (0.9)	25 (0.4)	**0.02**
Fluoroquinolone resistance	56 (25.5)	113 (13.1)	**<0.0001**
TMP-SMX resistance	49 (22.3)	101 (11.7)	**<0.0001**

Thévenot et al, 2025

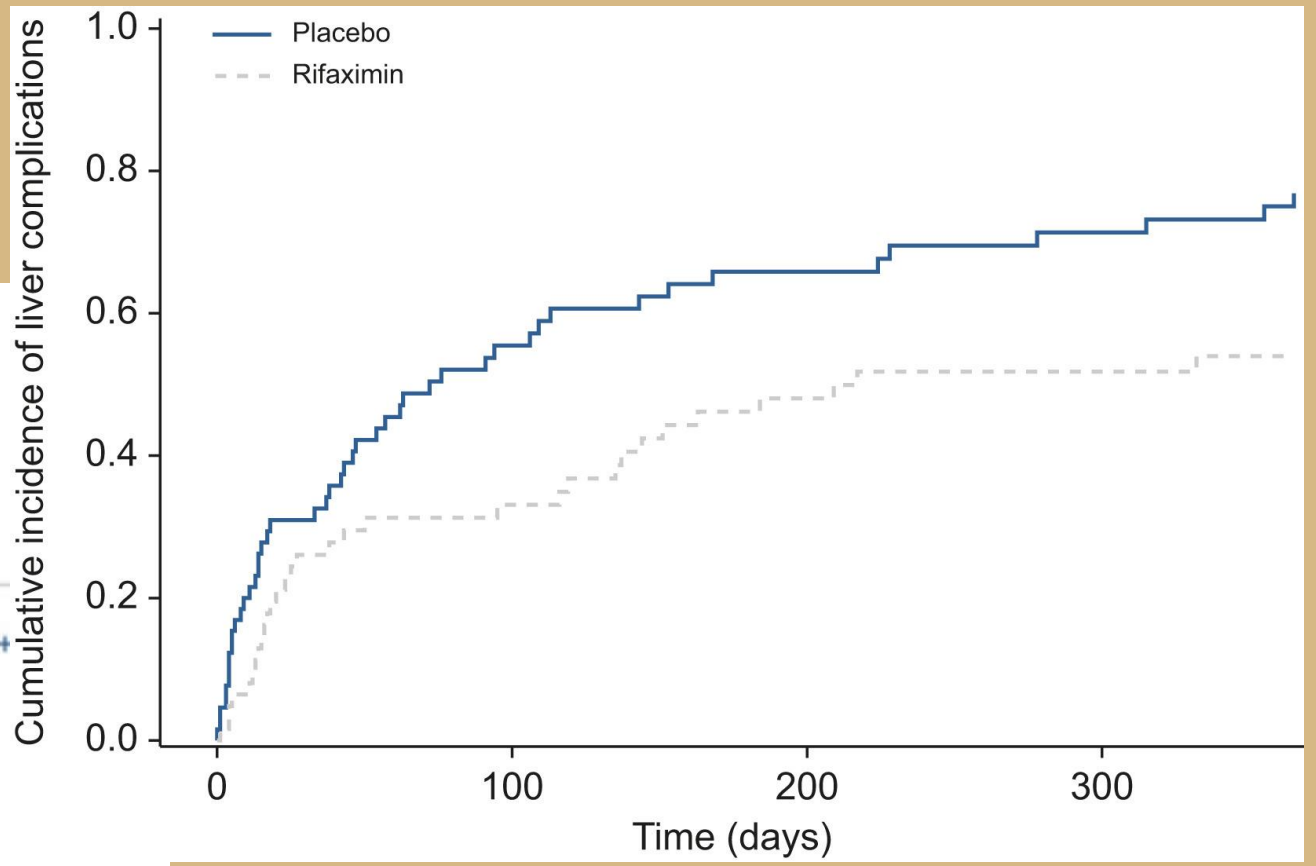




Thévenot et al, 2025



No. at risk								
Placebo	80	66	53	51	47	45	44	39
Rifaximin	72	59	52	49	46	38	35	29



To Watch: ASEPTIC Trial

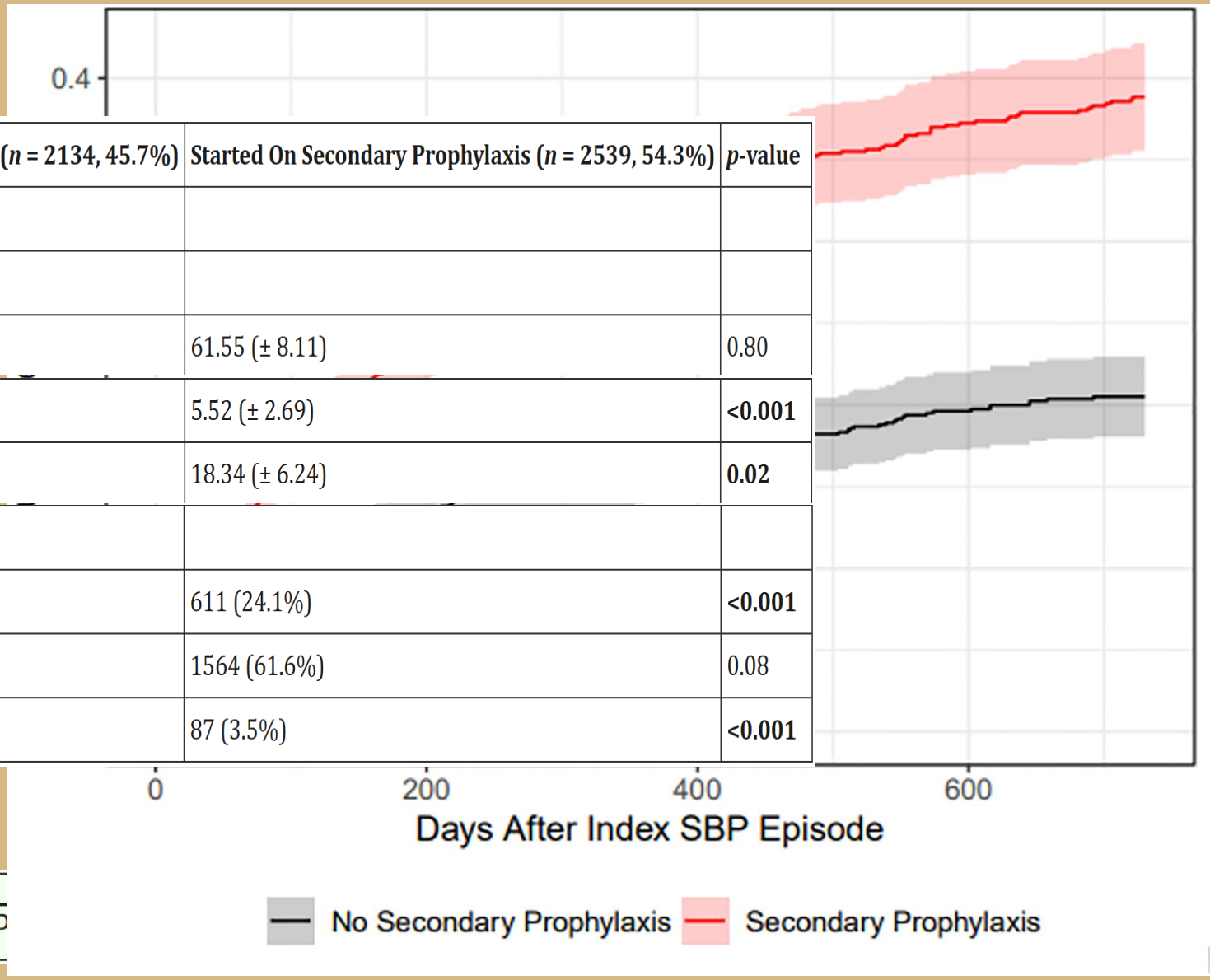
- Co-trimoxazole vs placebo for primary SBP prophylaxis

Secondary Prophylaxis

Silvey et al, 2024

VA Data

n = 4673 patients with first SBP episode	Not started on Secondary Prophylaxis (*n* = 2134, 45.7%)	Started On Secondary Prophylaxis (*n* = 2539, 54.3%)	*p*-value
Variable			
Labs / Demographics			
Age	61.49 (± 9.13)	61.55 (± 8.11)	0.80
Charlson Comorbidity Index	5.02 (± 2.65)	5.52 (± 2.69)	**<0.001**
MELD-Na	17.87 (± 6.78)	18.34 (± 6.24)	**0.02**
Outcomes			
2-Year SBP Recurrence	293 (13.7%)	611 (24.1%)	**<0.001**
2-Year All-Cause Mortality	1261 (59.1%)	1564 (61.6%)	0.08
2-Year Liver Transplant	33 (1.5%)	87 (3.5%)	**<0.001**



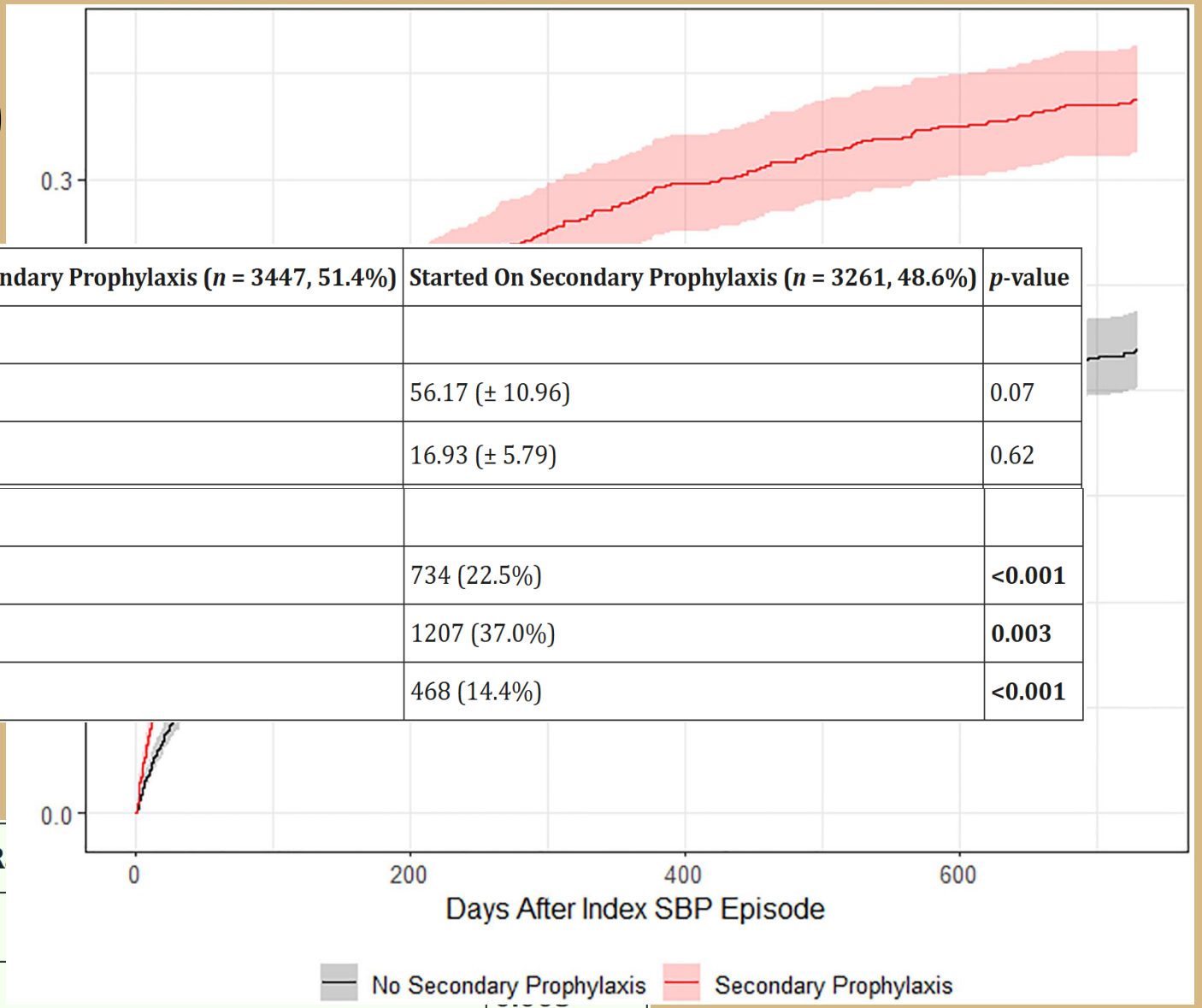
SBP recurrence	1.82 [1.5

Silvey et al, 20

Non-VA Data

n = 6708 patients with first SBP episode	Not started on Secondary Prophylaxis (*n* = 3447, 51.4%)	Started On Secondary Prophylaxis (*n* = 3261, 48.6%)	*p*-value
Labs / Demographics			
Age	56.66 (± 11.47)	56.17 (± 10.96)	0.07
MELD-XI Score	16.84 (± 6.34)	16.93 (± 5.79)	0.62
Outcomes			
2-Year SBP Recurrence	551 (16.0%)	734 (22.5%)	**<0.001**
2-Year All-Cause Mortality	1157 (33.6%)	1207 (37.0%)	**0.003**
2-Year Liver Transplant	191 (5.5%)	468 (14.4%)	**<0.001**

Outcome	Hazard or Odds R
SBP recurrence	1.61 [1.44 – 1.80]
All-Cause Mortality	1.16 [1.05 – 1.29]



Avoid unnecessary PPIs

Badal

	On primary prophylaxis (n=1367), n (%)	Not on primary prophylaxis (n=6192), n (%)	*p*
PPI	549 (40.2)	1425 (23.0)	**<0.0001**

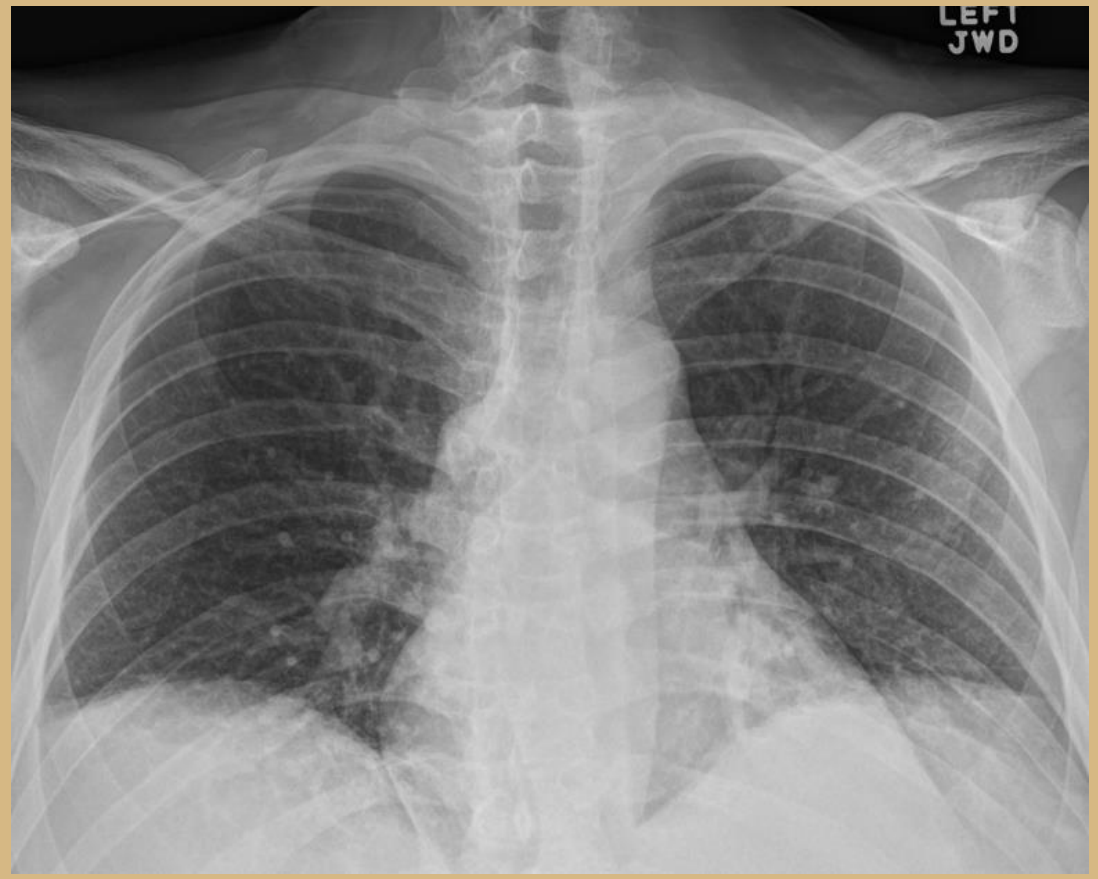
Silvey, VA Data

***n* = 4673 patients with first SBP episode**	**Not started on Secondary Prophylaxis (*n* = 2134, 45.7%)**	**Started On Secondary Prophylaxis (*n* = 2539, 54.3%)**	***p*-value**
Proton Pump Inhibitors	772 (36.2%)	1028 (40.5%)	**0.003**

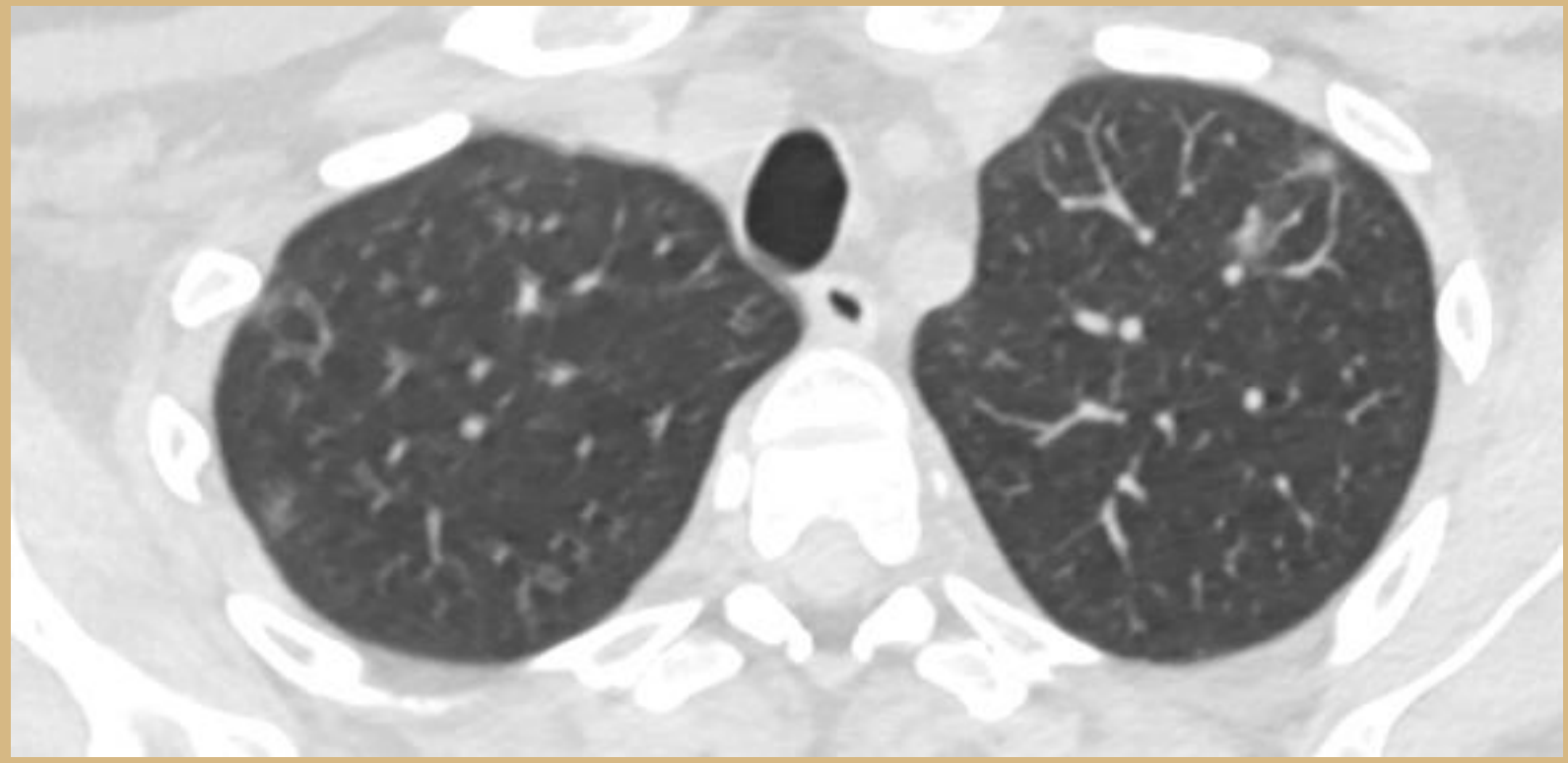
Silvey, Non-VA Data

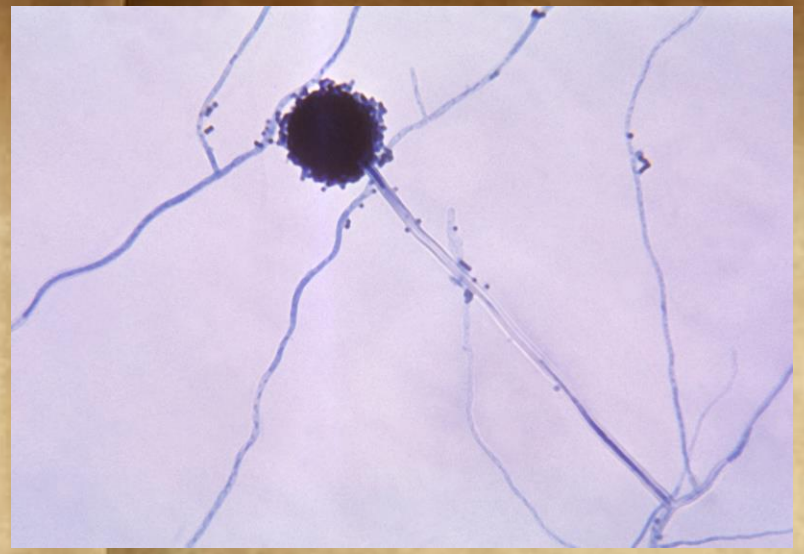
***n* = 6708 patients with first SBP episode**	**Not started on Secondary Prophylaxis (*n* = 3447, 51.4%)**	**Started On Secondary Prophylaxis (*n* = 3261, 48.6%)**	***p*-value**
Proton Pump Inhibitor	1331 (38.6%)	1734 (53.2%)	**<0.001**

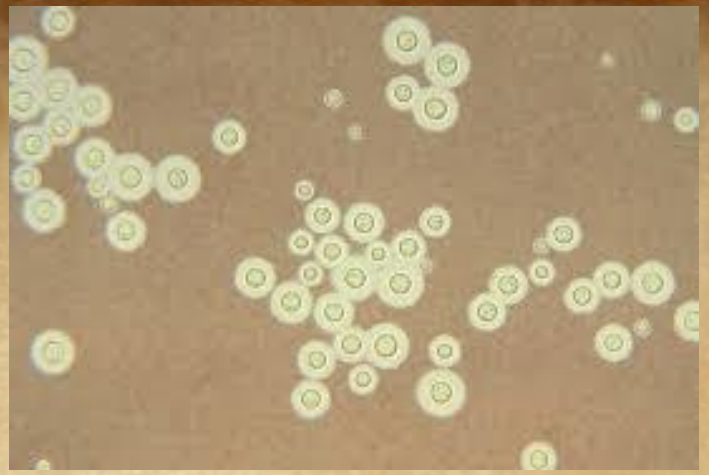
- He returns to GI clinic 1 month later with worsening jaundice (Bili 27 -> 33), fatigue, myalgias and is promptly admitted. MELD-Na is 27. WBC count 29k. He notes suprapubic tenderness and urinary frequency. UA bland. Started on empiric ceftriaxone.

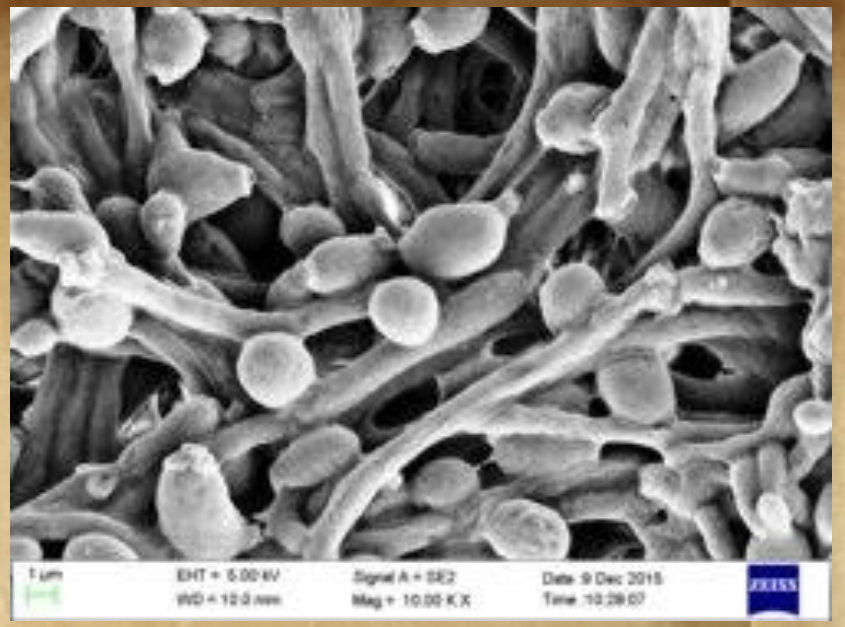


- Infectious workup expanded and including CT chest. WBC 14.6 and no significant improvement despite prior antibiotics. Transplant team recommends fungal workup.

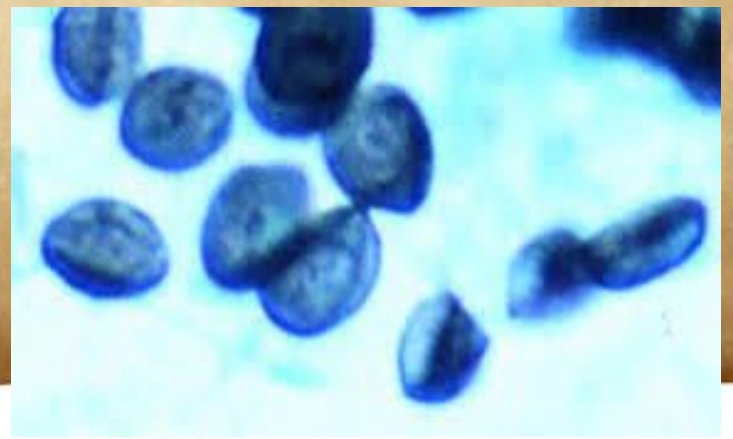








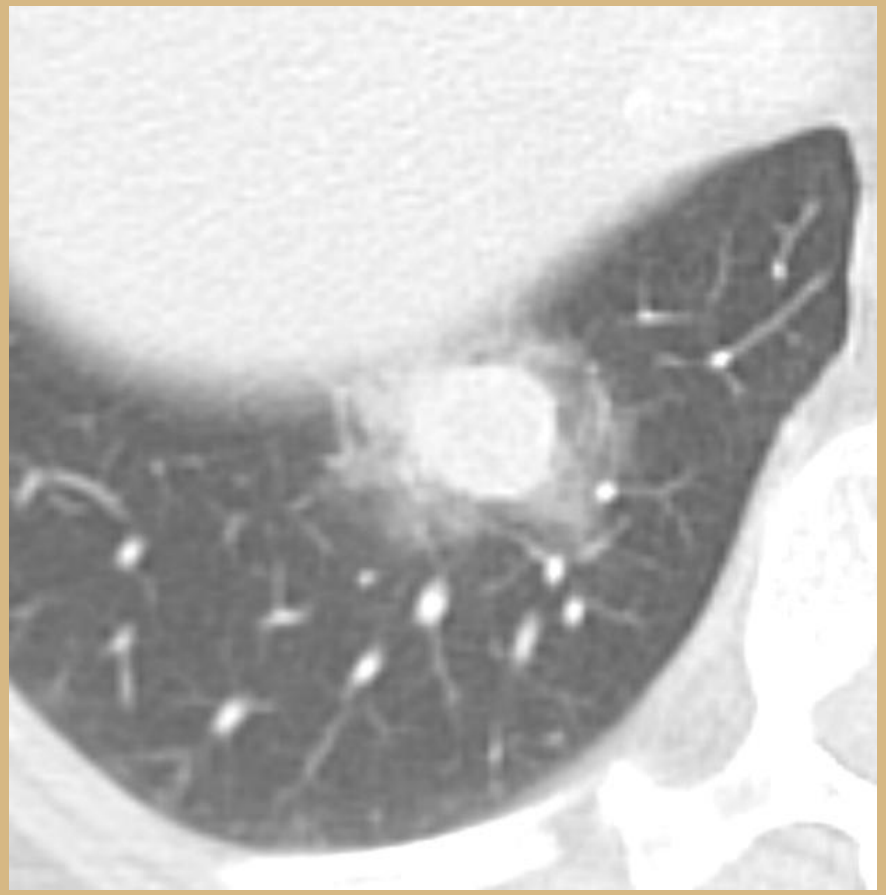
Fungal Infections



Invasive Fungal Infections in Liver Disease

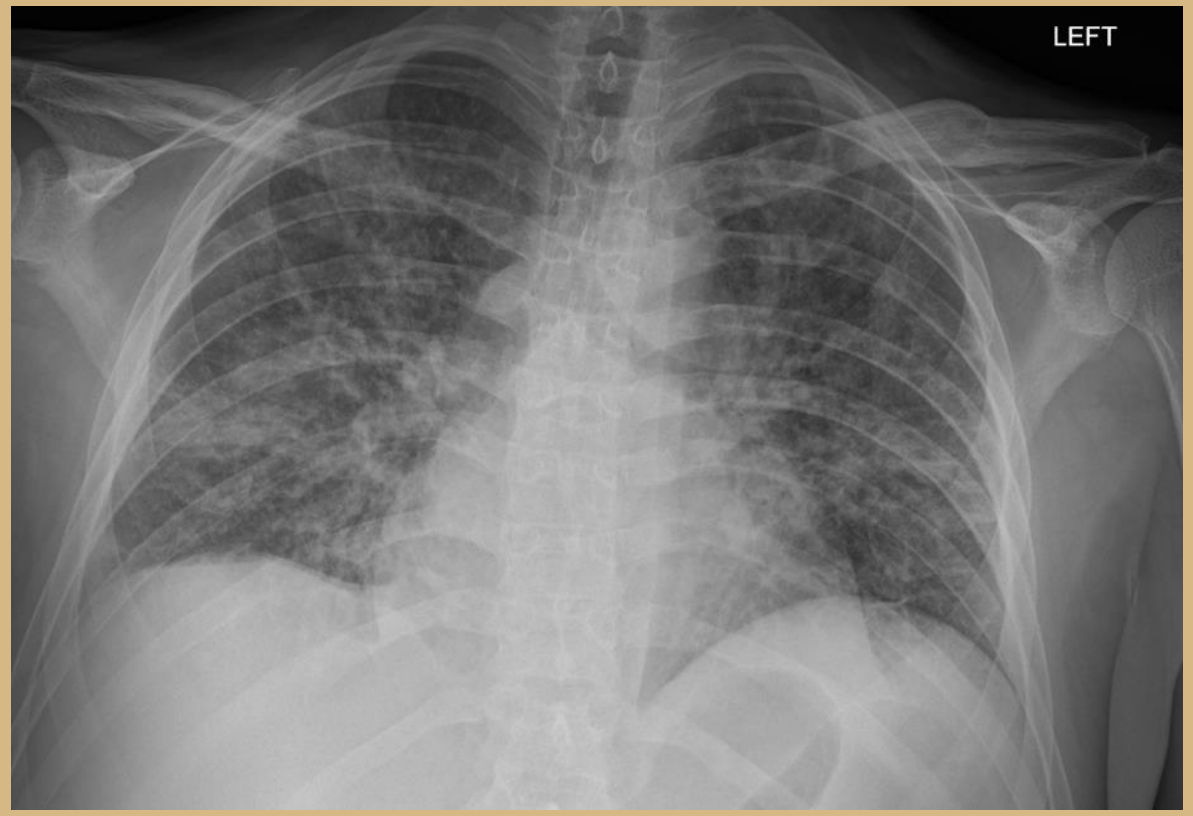
- 31,984 patients with cirrhosis
  - Invasive Candidiasis: 2-8%
  - Invasive Aspergillosis: 1.5-5.3%
  - SFP: ?3.5% of spontaneous peritonitis
  - Cryptococcus sometimes manifesting as “refractory HE”
- However, mortality is high:
  - 30% for all fungal infections
    - 21-34% 90-d for invasive candidiasis
  - >50% for fungemia, fungal peritonitis
    - (3x higher than bacterial peritonitis)
  - ACLF + acute decompensation: 71% 90d mortality

Invasive Pulmonary Aspergillosis

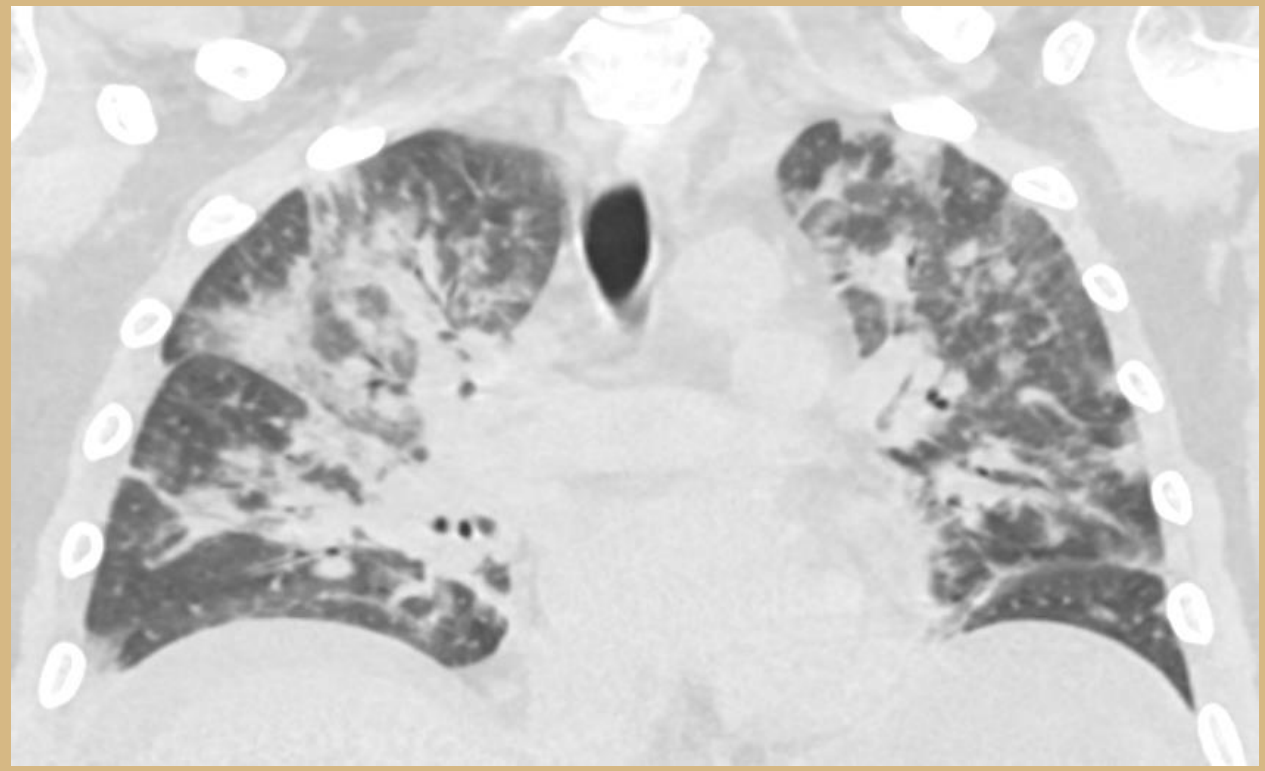


Aspergillosis

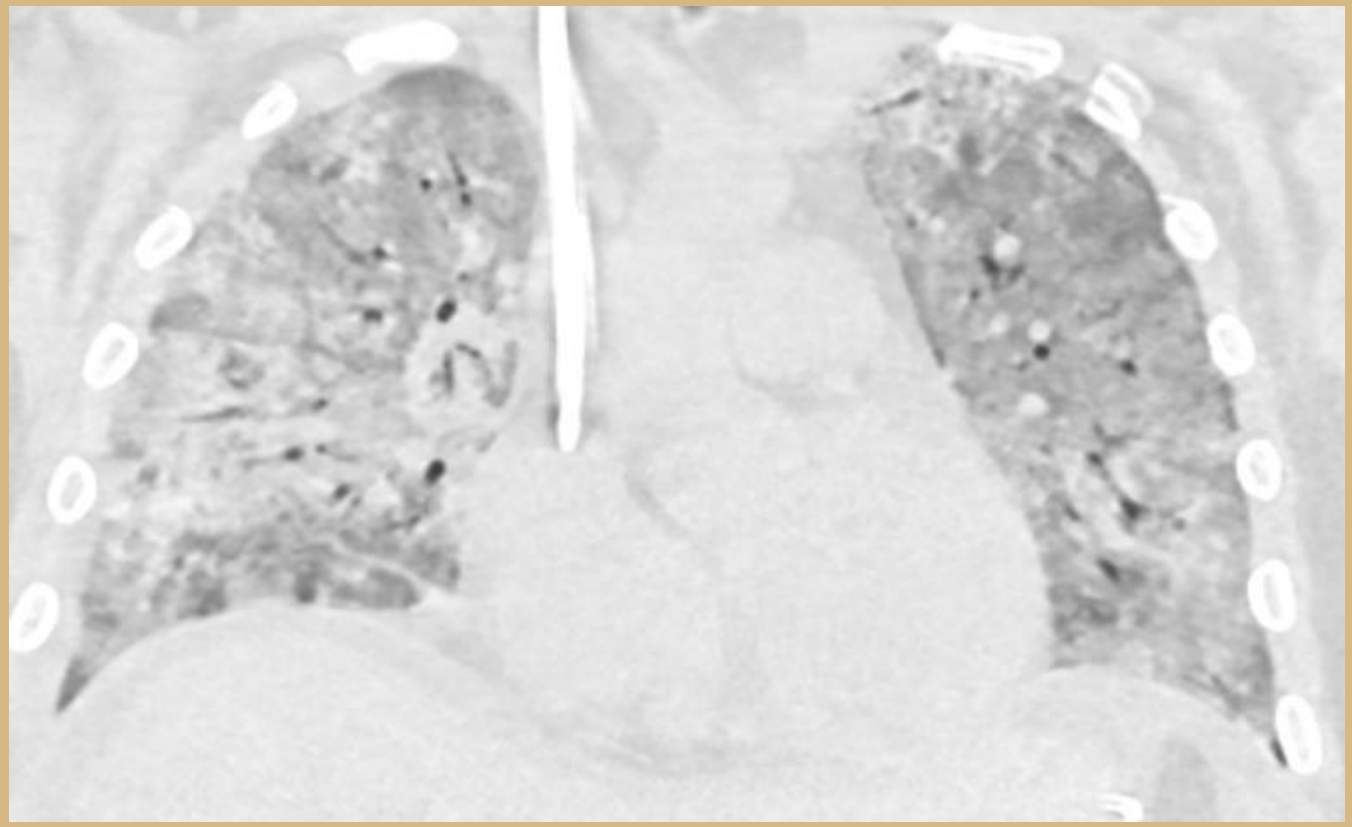
- Starting a week after admission, he begins to describe an intermittent dry cough. At almost the same time, his beta-D-glucan returns elevated at 195.



- ABG shows significant A-a gradient despite him remaining on room air.



- PJP positive on BAL. He, unfortunately, continues to decline and passes away.



They're more like guidelines
than actual rules...

Questions?

VOCAL Penn Cohort

Variable	Overall (n = 4,712)	Derivation (n = 3,770)	Validation (n = 942)
Age, median (IQR)	64 (60, 69)	64 (60, 69)	64 (60, 69)
Male sex	4,582 (97.2%)	3,667 (97.3%)	915 (97.1%)
Race			
White	2,981 (63.3%)	2,365 (62.7%)	616 (65.4%)
Black	741 (15.7%)	604 (16.0%)	137 (14.5%)
Hispanic	323 (6.9%)	250 (6.6%)	73 (7.7%)
Asian	51 (1.1%)	43 (1.1%)	8 (0.8%)
Other	616 (13.1%)	508 (13.5%)	108 (11.5%)
Smoking history			
Never smoker	846 (18.8%)	676 (18.8%)	170 (19.0%)
Former smoker	979 (21.8%)	768 (21.3%)	211 (23.5%)
Current smoker	2,676 (59.5%)	2,160 (59.9%)	516 (57.5%)
Hazardous alcohol use	821 (18.0%)	658 (18.1%)	163 (18.0%)
Surgery category			
Abdominal—laparoscopic	476 (10.1%)	387 (10.3%)	89 (9.4%)
Abdominal—open	665 (14.1%)	531 (14.1%)	134 (14.2%)
Abdominal wall	1,308 (27.8%)	1,054 (28.0%)	254 (27.0%)
Vascular	550 (11.7%)	442 (11.7%)	108 (11.5%)
Major orthopedic	1,298 (27.5%)	1,032 (27.4%)	266 (28.2%)
Chest/cardiac	415 (8.8%)	324 (8.6%)	91 (9.7%)
Emergency surgery	476 (10.1%)	388 (10.3%)	88 (9.3%)
ASA classification (ordinal)			
2	200 (4.2%)	161 (4.3%)	39 (4.1%)
3	3,196 (67.8%)	2,578 (68.4%)	618 (65.6%)
4	1,316 (27.9%)	1,031 (27.3%)	285 (30.3%)
ASA reclassified (binary)*			
3	2,147 (45.6%)	1,725 (45.8%)	422 (44.8%)
4	2,565 (54.4%)	2,045 (54.2%)	520 (55.2%)

VOCAL Penn Cohort

TABLE 1. Cohort Characteristics

Variable	Overall (n = 4,712)	Derivation (n = 3,770)	Validation (n = 942)
Sodium, median (IQR)	138 (136, 140)	138 (136, 140)	138 (136, 140)
Creatinine, median (IQR)	1.0 (0.8, 1.2)	0.96 (0.8, 1.2)	1 (0.8, 1.2)
AST, median (IQR)	32 (22.5, 50)	32 (23, 50)	32 (22.5, 48)
ALT, median (IQR)	27 (18, 43)	27 (18, 43)	27 (18, 42)
Total bilirubin, median (IQR)	0.8 (0.5, 1.1)	0.75 (0.5, 1.1)	0.75 (0.5, 1.2)
Albumin, median (IQR)	3.7 (3.2, 4.1)	3.7 (3.2, 4.1)	3.7 (3.15, 4.10)
Platelet count, median (IQR)	152 (107, 207)	151 (106, 205.5)	156 (112, 213)
INR, median (IQR)	1.1 (1.0, 1.2)	1.1 (1.02, 1.245)	1.1 (1.02, 1.24)
MELD, median (IQR)	8 (7, 11)	8 (7, 11)	9 (7, 11)
MELD-Na, median (IQR)	10 (8, 14)	10 (8, 14)	11 (8, 14)
CTP class			
A	4,159 (88.3%)	3,344 (88.7%)	815 (86.5%)
B	530 (11.2%)	406 (10.8%)	124 (13.2%)
C	23 (0.5%)	20 (0.5%)	3 (0.3%)
Ascites category			
None	4,092 (86.8%)	3,272 (86.8%)	820 (87.0%)
Slight	469 (10.0%)	389 (10.3%)	80 (8.5%)
Moderate	151 (3.2%)	109 (2.9%)	42 (4.5%)
HE			
No encephalopathy	4,577 (97.1%)	3,660 (97.1%)	917 (97.3%)
Grade 1-2	122 (2.6%)	98 (2.6%)	24 (2.5%)
Grade 3-4	13 (0.3%)	12 (0.3%)	1 (0.1%)

VOCAL Penn Cohort

TABLE 1. Cohort Characteristics

Variable	Overall (n = 4,712)	Derivation (n = 3,770)	Validation (n = 942)
Etiology of liver disease			
Hepatitis C	612 (13.0%)	497 (13.2%)	115 (12.2%)
Hepatitis B	73 (1.5%)	58 (1.5%)	15 (1.6%)
Alcohol	1,662 (35.3%)	1,318 (35.0%)	344 (36.5%)
Hepatitis C + alcohol	1,388 (29.5%)	1,110 (29.4%)	278 (29.5%)
Fatty liver disease	585 (12.4%)	480 (12.7%)	105 (11.1%)
Other	392 (8.3%)	307 (8.1%)	85 (9.0%)
History of previous decompensation	2,066 (43.8%)	1,653 (43.8%)	413 (43.8%)
Hypertension	3,904 (85.4%)	3,120 (85.2%)	784 (86.3%)
Diabetes	2,355 (51.7%)	1,882 (51.6%)	473 (52.2%)
Obesity (BMI ≥ 30)	3,359 (73.8%)	2,704 (74.2%)	655 (72.3%)
Atrial fibrillation	803 (17.0%)	651 (17.3%)	152 (16.1%)
Coronary artery disease	1,622 (34.4%)	1,291 (34.2%)	331 (35.1%)
Congestive heart failure	1,239 (26.3%)	985 (26.1%)	254 (27.0%)

U Penn + Beth Israel

Cirrhosis Surgery Cohort Characteristics, with Comparison to the Veterans Affairs C

Factor	Veterans Affairs (N=4712)		BIDMC (N=304)	UPHS (N=551)	p-value *
Age, median (IQR)	64 (60, 69)		60 (54, 67)	62 (56, 68)	0.02
Male Sex	4582 (97.2%)		197 (64.8%)	349 (63.3%)	0.67
Race					<0.001
White	2981 (63.3%)		229 (75.3%)	348 (63.2%)	
Black	741 (15.7%)		28 (9.2%)	181 (32.8%)	
Asian	51 (1.1%)		7 (2.3%)	6 (1.1%)	
Other	939 (19.9%)		40 (13.2%)	16 (2.9%)	
Surgery Type					<0.001
Chest/Cardiac	415 (8.8%)		36 (11.8%)	68 (12.3%)	
Abdominal - Open	665 (14.1%)		65 (21.4%)	134 (24.3%)	
Major Orthopedic	1298 (27.5%)		52 (17.1%)	168 (30.5%)	
Vascular	550 (11.7%)		7 (2.3%)	34 (6.2%)	
Abdominal Wall	1308 (27.8%)		89 (29.3%)	88 (16.0%)	
Abdominal - Laparoscopic	476 (10.1%)		55 (18.1%)	59 (10.7%)	
ASA Classification					0.21
2	200 (4.2%)		32 (10.5%)	44 (8.0%)	
3	3196 (67.8%)		187 (61.5%)	370 (67.2%)	
4	1316 (27.9%)		85 (28.0%)	137 (24.9%)	

U Penn + Beth

Factor	Veterans Affairs (N=4712)
Total Bilirubin, median (IQR)	0.8 (0.5, 1.1)
Platelet Count, median (IQR)	152 (107, 207)
INR, median (IQR)	1.1 (1.0, 1.2)

BIDMC (N=304)	UPHS (N=551)	p-value *
1.1 (0.6, 2.0)	0.9 (0.6, 1.8)	0.02
129 (83.5, 196.5)	141 (98, 201)	0.04
1.3 (1.1, 1.5)	1.2 (1.1, 1.4)	<0.001

Emergency Status	476 (10.1%)		47 (15.5%)	79 (14.3%)	0.66
Etiology of Liver Disease					<0.001
NAFLD	585 (12.4%)		81 (26.6%)	180 (32.7%)	
Alcohol	1662 (35.3%)		110 (36.2%)	120 (21.8%)	
Autoimmune	122 (2.6%)		19 (6.2%)	40 (7.3%)	
Hepatitis B	73 (1.5%)		3 (1.0%)	16 (2.9%)	
Hepatitis C	2000 (42.4%)		91 (29.9%)	180 (32.7%)	
Other	270 (5.7%)		0 (0.0%)	15 (2.7%)	
Ascites	620 (13.2%)		105 (34.5%)	181 (32.8%)	0.62
Obesity	3359 (73.8%)		118 (38.8%)	281 (51.0%)	<0.001
Diabetes Mellitus	2355 (51.7%)		103 (33.9%)	266 (48.3%)	<0.001
Hypertension	3904 (85.4%)		172 (56.6%)	360 (65.3%)	0.01
Heart Failure	1239 (26.3%)		51 (16.8%)	154 (27.9%)	<0.001
MELD, median (IQR)	8 (7, 11)		11(8, 16)	11 (8, 16)	0.56
MELD-Na, median (IQR)	10 (8, 14)		12 (9, 19)	12 (9, 18)	0.78
Sodium, median (IQR)	138 (136, 140)		137 (135, 140)	137 (135, 140)	0.60
Creatinine, median (IQR)	1.0 (0.8, 1.2)		0.9 (0.7, 1.2)	1.0 (0.8, 1.4)	0.002
Albumin, median (IQR)	3.7 (3.2, 4.1)		3.5 (3.0, 4.0)	3.4 (2.9, 3.9)	0.05

Barcelona

	H. Mar Cohort (n = 512)	VOCAL-Penn Cohort (n = 4712)	*p*
Age (years)	66 (57–75)	64 (60–69)	<0.001
Male sex, n (%)	332 (64.8)	4582 (97.2%)	<0.001
Etiology of liver disease, n (%) (n = 510)			
Hepatitis C	149 (29.2)	612 (13.0)	<0.001
Hepatitis B	11 (2.2)	73 (1.5)	0.227
Alcohol	231 (45.3)	1662 (35.3)	<0.001
MAFLD	52 (10.8)	585 (12.4)	0.255
Hepatitis C + Alcohol	36 (7.1)	1388 (29.5)	<0.001
Other	28 (5.5)	392 (8.3)	0.020
Creatinine (mg/dL)	0.87 (0.69–1.16)	1.0 (0.8–1.2)	<0.001
Total bilirubin (mg/dL) (n = 454)	0.82 (0.50–1.39)	0.8 (0.5–1.1)	<0.001
Albumin (g/dL) (n = 447)	4.0 (3.3–4.4)	3.7 (3.2–4.1)	0.005
INR (n = 509)	1.17 (1.08–1.32)	1.1 (1.0–1.2)	<0.001
Platelet count ($\cdot 10^3$/μL) (n = 507)	132.0 (93.0–195.0)	152.0 (107.0–207.0)	0.013
MELD (n = 454)	10 (8–13)	8 (7–11)	<0.001
MELD-Na (n = 454)	12 (8–16)	10 (8–14)	<0.001
Child-Pugh class, n (%) (n = 420)			
A	297 (70.7)	4159 (88.3)	<0.001
B	104 (24.8)	530 (11.2)	<0.001
C	19 (4.5)	23 (0.5)	<0.001
Ascites 30 days before surgery, n (%)	78 (15.2)	620 (13.2)	0.174
History of previous decompensation, n (%)	150 (29.3)	2066 (43.8)	<0.001

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	H. Mar Cohort (n = 512)	VOCAL-Penn Cohort (n = 4712)	*p*
Endoscopic signs of portal hypertension, n (%) (n = 422)	247 (58.5)	-	-
Hypertension, n (%)	242 (47.3)	3904 (85.4)	<0.001
Diabetes, n (%)	151 (29.5)	2355 (51.7)	<0.001
Obesity (BMI ≥ 30 kg/m^2), n (%) (n = 454)	142 (31.3)	3359 (73.8)	<0.001
Chronic kidney disease, n (%)	77 (15.0)	-	-
Peripheral vascular disease, n (%)	41 (8.0)	-	-
Previous acute myocardial infarction, n (%)	26 (5.1)	1622 (34.4)	<0.001
Congestive heart failure, n (%)	29 (5.7)	1239 (26.3)	<0.001
Active cancer, n (%)	107 (20.9)	-	-
ASA-IV	124 (24.2)	2565 (54.4)	<0.001
Surgery category, n (%)			
Abdominal–Laparoscopic	94 (18.4)	47 (10.1)	<0.001
Abdominal–Open	124 (24.2)	665 (14.1)	<0.001
Abdominal wall	111 (21.7)	1308 (27.8)	0.002
Vascular	31 (6.1)	550 (11.7)	<0.001
Major orthopedic	128 (25.0)	1298 (27.5)	0.205
Thoracic/Cardiac	24 (4.7)	415 (8.8)	0.003
Emergent surgery, n (%)	206 (40.2)	476 (10.1)	<0.001

Cleveland Clinic, Cardiac

TABLE 1. Demographics and preoperative comorbidities of 220 patients with cirrhosis undergoing cardiac surgery

Characteristic	Value
Demographics	
Caucasian race, n (%)	175 (79.5)
Female sex, n (%)	85 (38.6)
Age, y, median (IQR)	64 (52.0-72.5)
BMI, median (IQR)	28.6 (22.9-36.1)
Comorbidities, n (%)	
Diabetes	84 (38.2)
Hypertension	159 (72.3)
Dialysis	19 (8.6)
Chronic lung disease	81 (36.8)
Stroke	44 (20.0)
Atrial fibrillation	85 (38.6)
NYHA class 1	17 (11.4)
Class 2	66 (44.5)
Class 3	57 (38.5)
Class 4	8 (5.4)
Ascites	59 (26.8)
Encephalopathy	15 (6.8)
Peripheral artery disease	26 (11.8)
Child-Pugh class A	143 (65.0)
Class B	73 (33.2)
Class C	4 (1.8)
LVEF, %, median (IQR)	60 (50.0-66.0)
MELD score, median (IQR)	10 (7.0-20.5)
Serum albumin, g/dL, median (IQR)	3.7 (2.9-4.3)
Total bilirubin, mg/dL, median (IQR)	0.7 (0.4-1.5)
AST, U/L, median (IQR)	31.0 (20.0-56.0)
ALT, U/L, median (IQR)	22 (12.0-37.0)
Serum creatinine, mg/dL, median (IQR)	1.1 (0.7-1.8)
Sodium, mEq/L, median (IQR)	138 (133.0-41.0)
Platelet count, median (IQR)	147 (92.0-233.0)
INR, median (IQR)	1.1 (1.0-1.3)