Trauma* Case Conference

*Some AI Evaluation too

Erkin Ötleş MD PhD
February 2026

Case 1

Case 1A: 20F Laboratory Explosion

Scene
Air compressor tank explosion, shrapnel, immediate EMS

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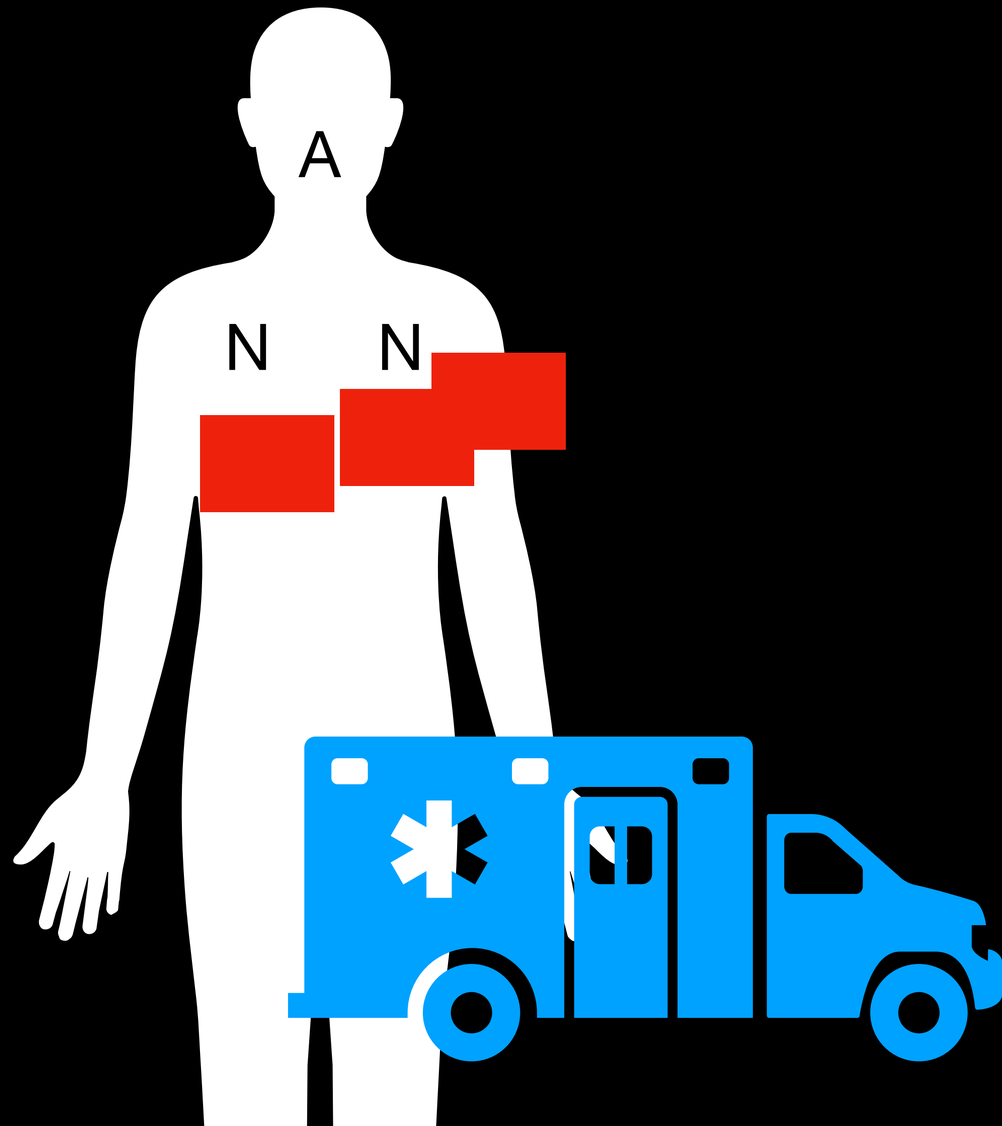
PEA, CPR, blood, needle decompressions



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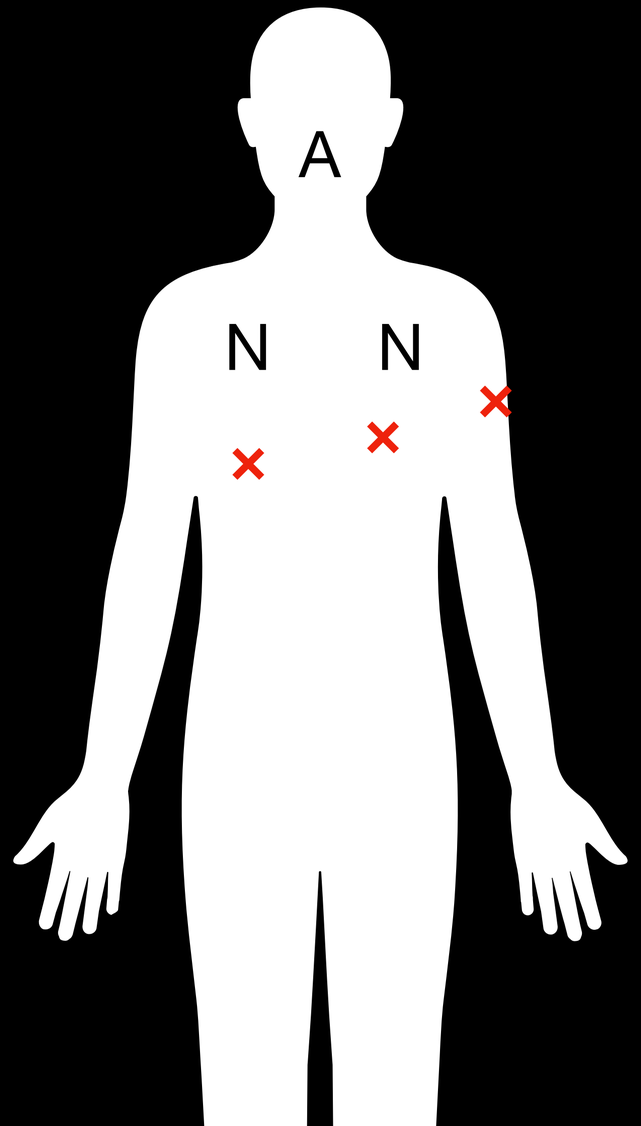

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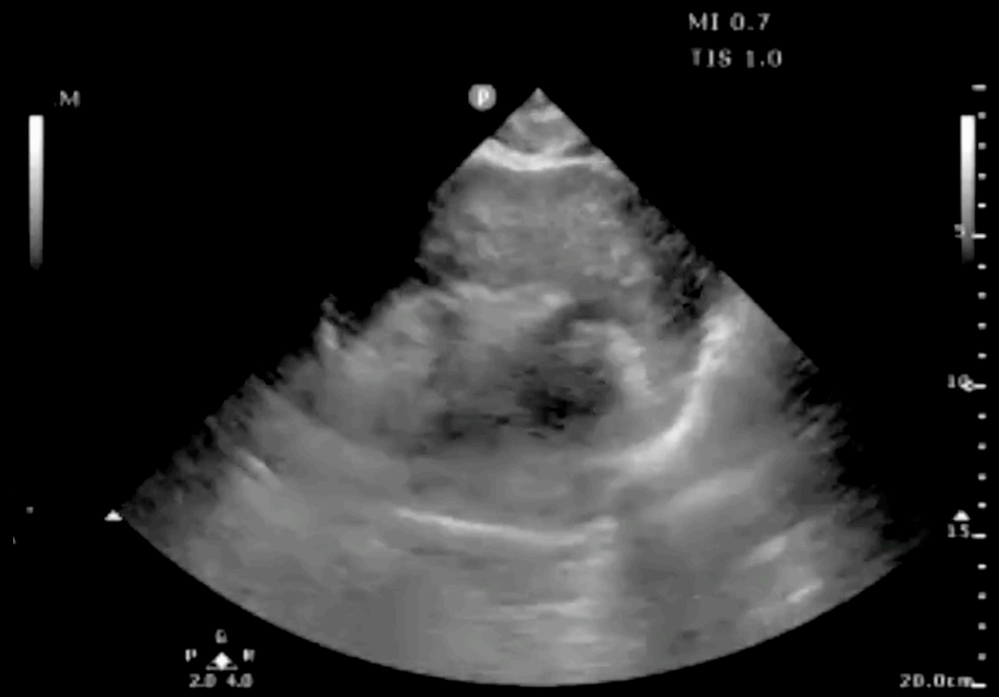

Tabbut, et al. 2023

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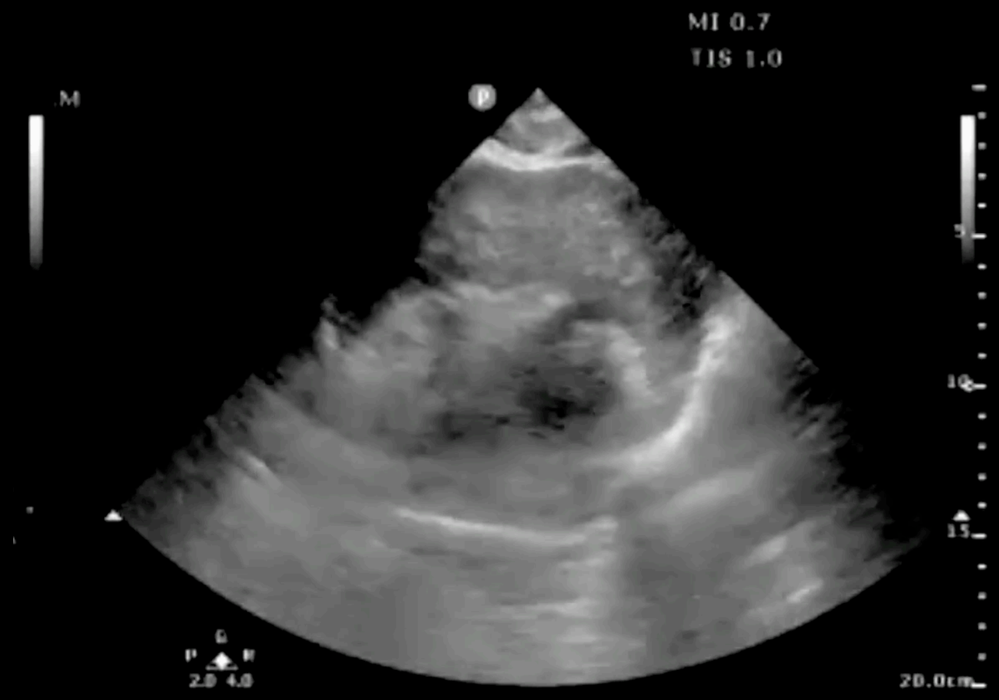
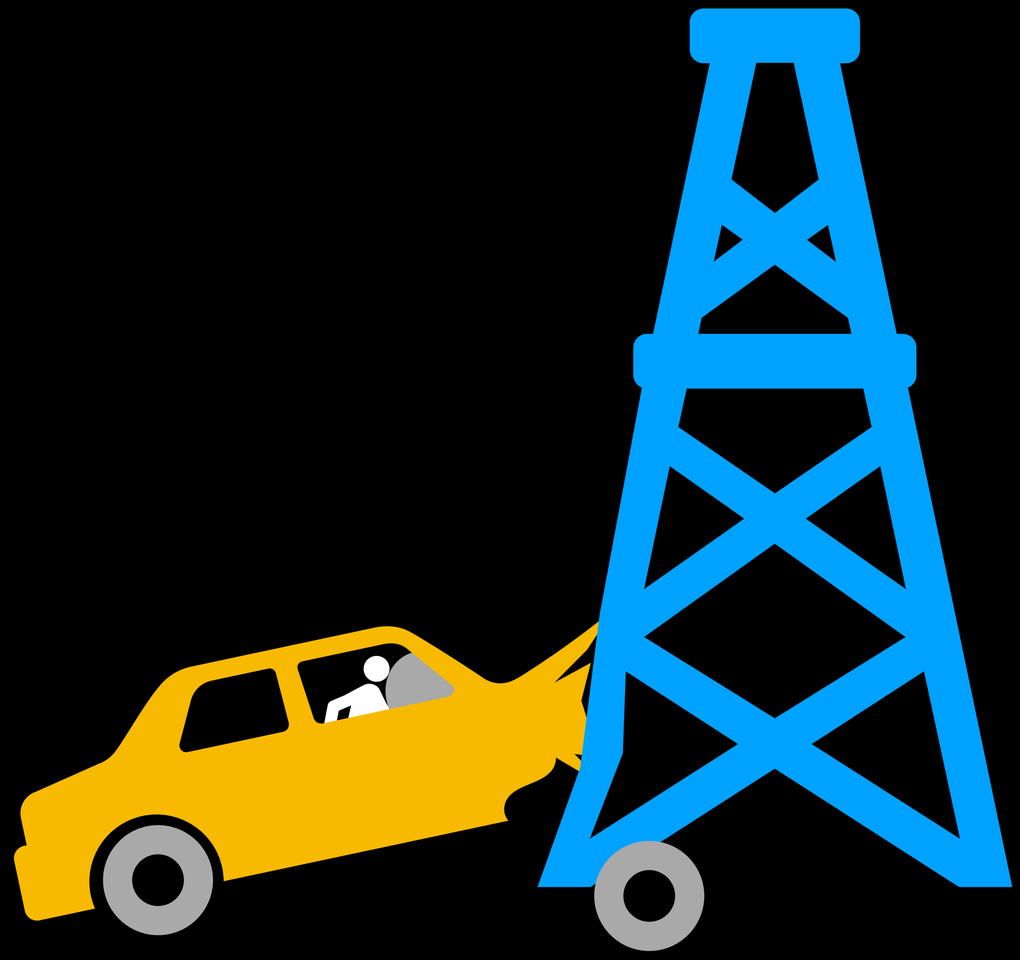


Tabbut, et al. 2023

Case 1B: 40M High Speed MVC

Scene
Intrusion, prolonged extrication



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Transient palpable pulse, then PEA, CPR
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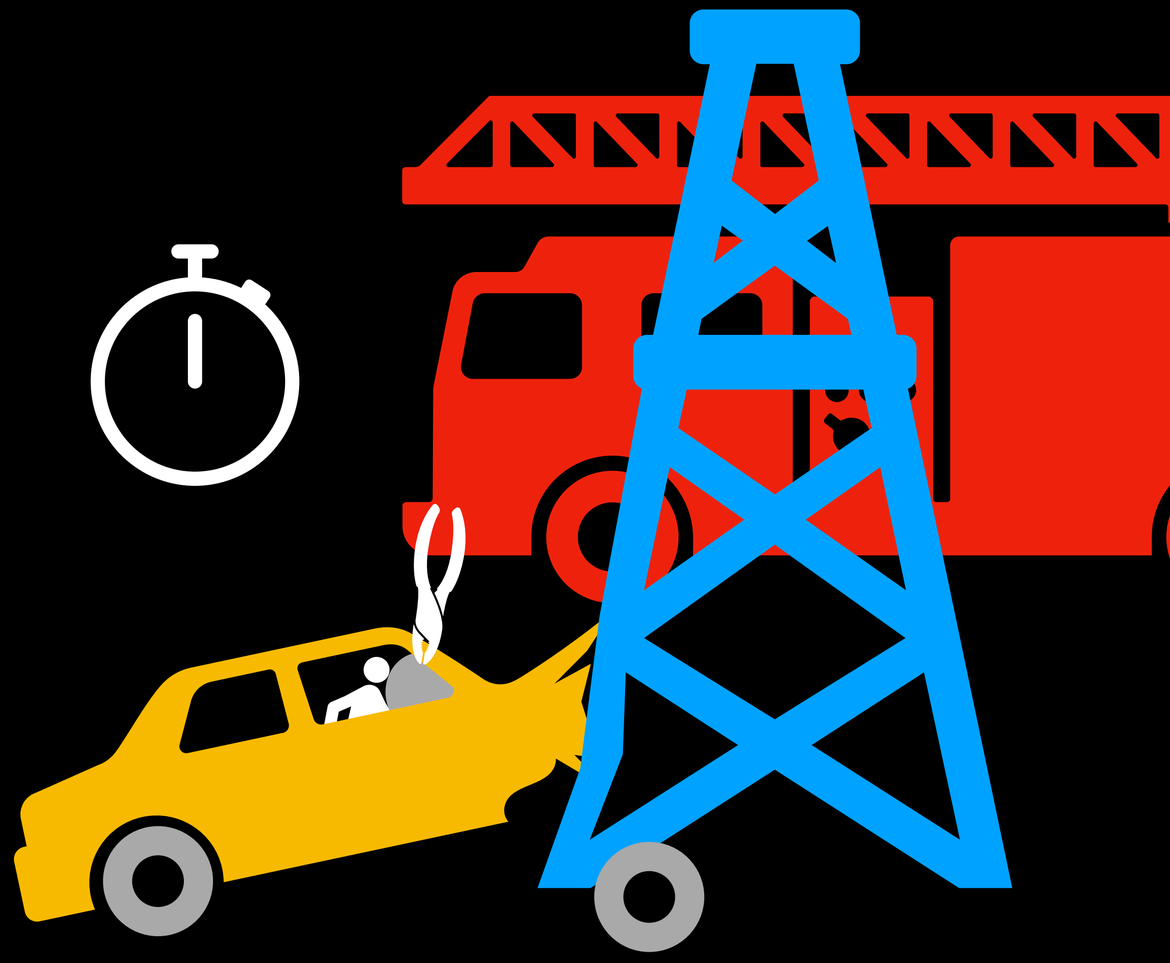

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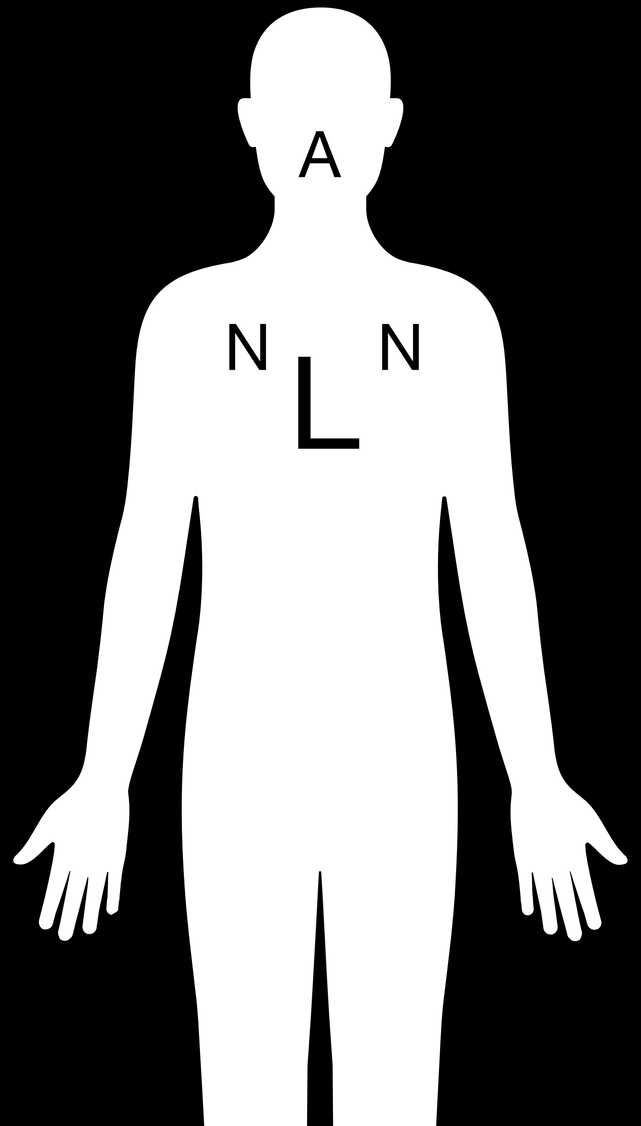

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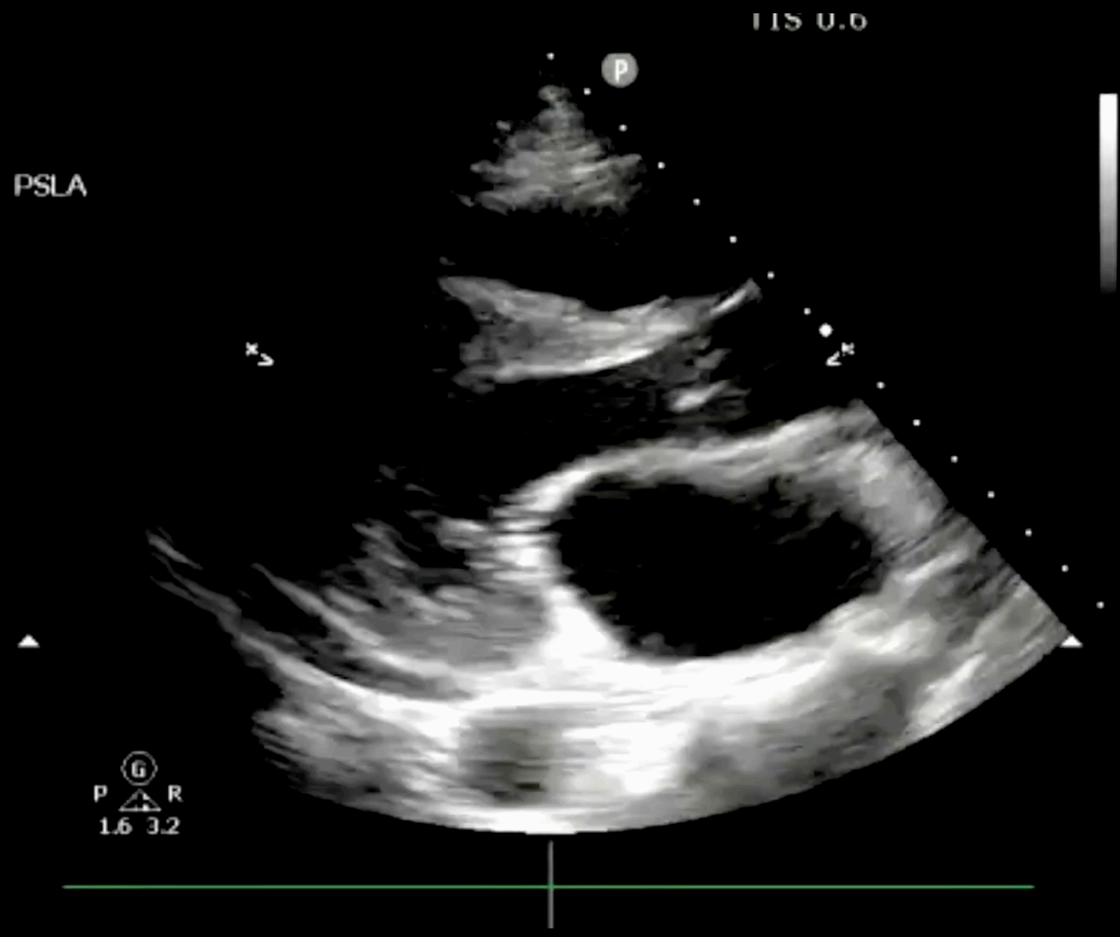
FAST: cardiac view



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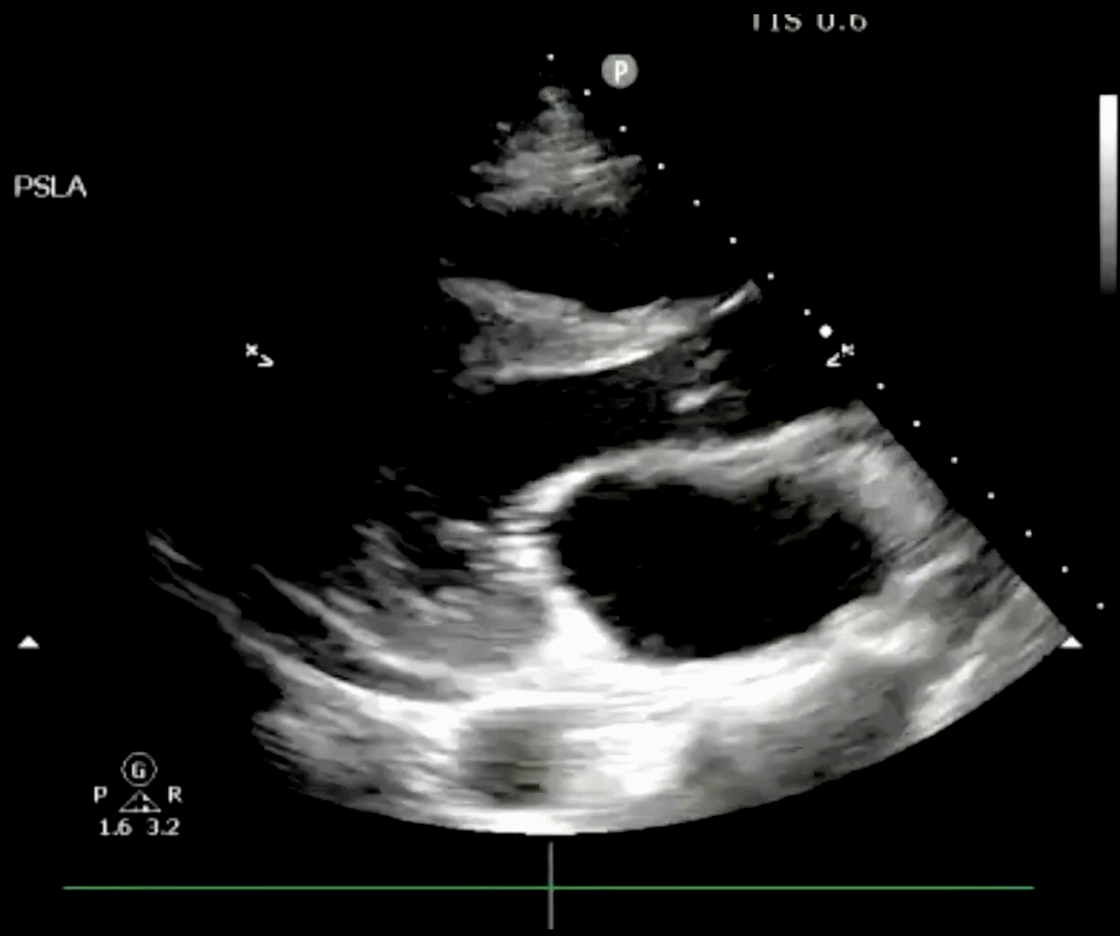

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Burlew, et al. 2012; Seamon, et al. 2015; Dewey et al., 2025

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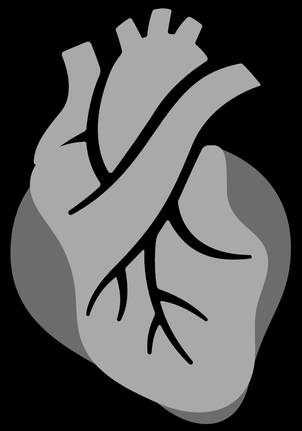

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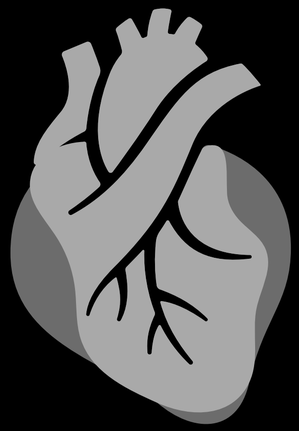

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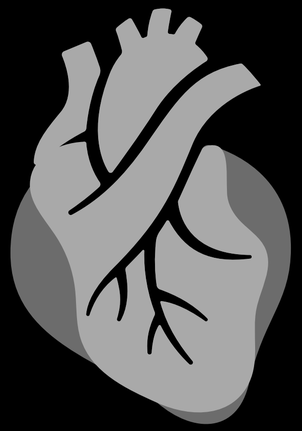

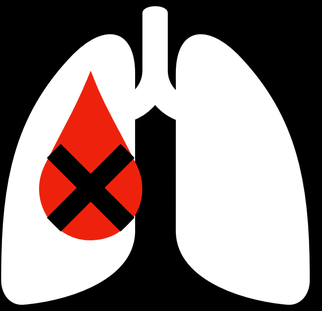

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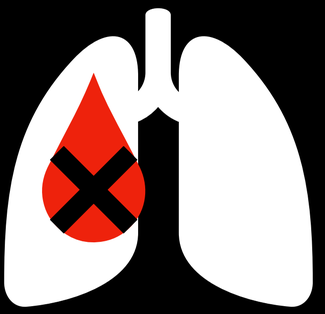

Traumatic arrest
Short timeframe to address reversible causes

Burlew, et al. 2012; Seamon, et al. 2015; Dewey, et al. 2025

What are EDT indications?

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Signs of Life (SoL):
Pupillary response, spontaneous breathing, palpable pulse/BP, extremity movement, organized electrical activity

Burlew, et al. 2012; Seamon, et al. 2015; Dewey, et al. 2025

What are EDT indications?

Mechanism + signs of life + CPR duration

Blunt trauma + pulseless

Consider EDT: SoL + CPR<10min

Recommend against: no SoL on arrival

Not never, but nearly never

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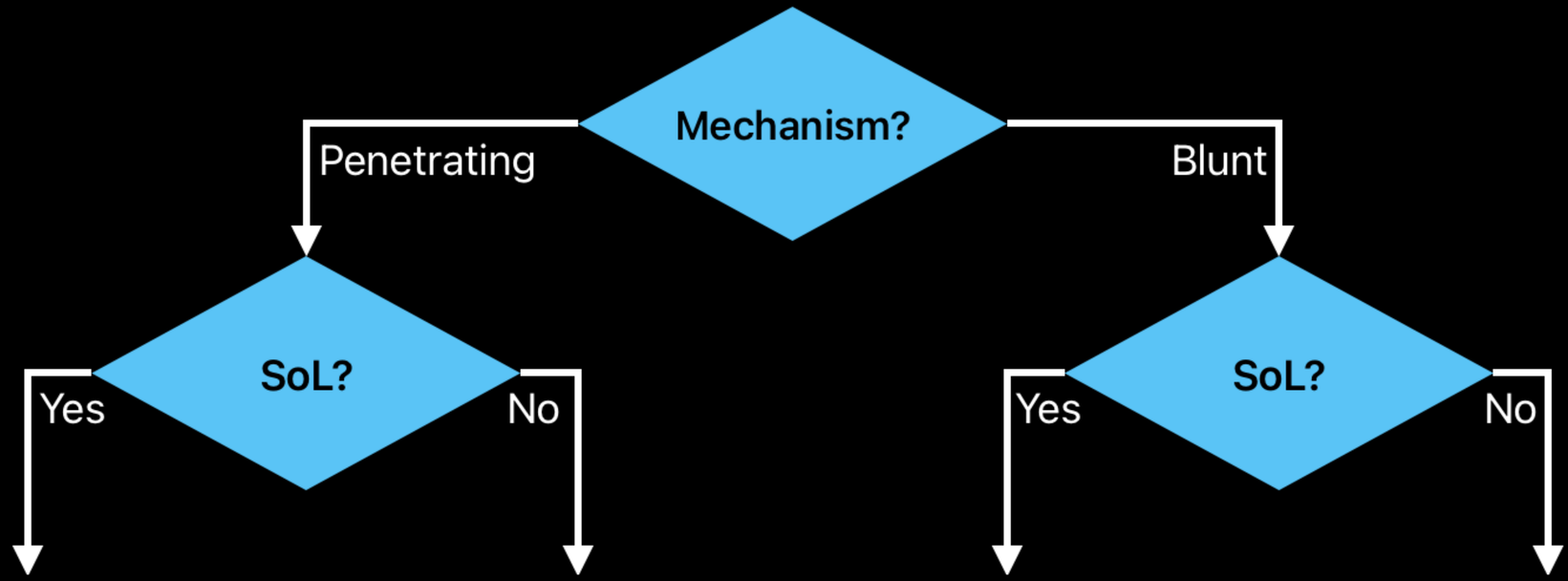
EDT Outcomes

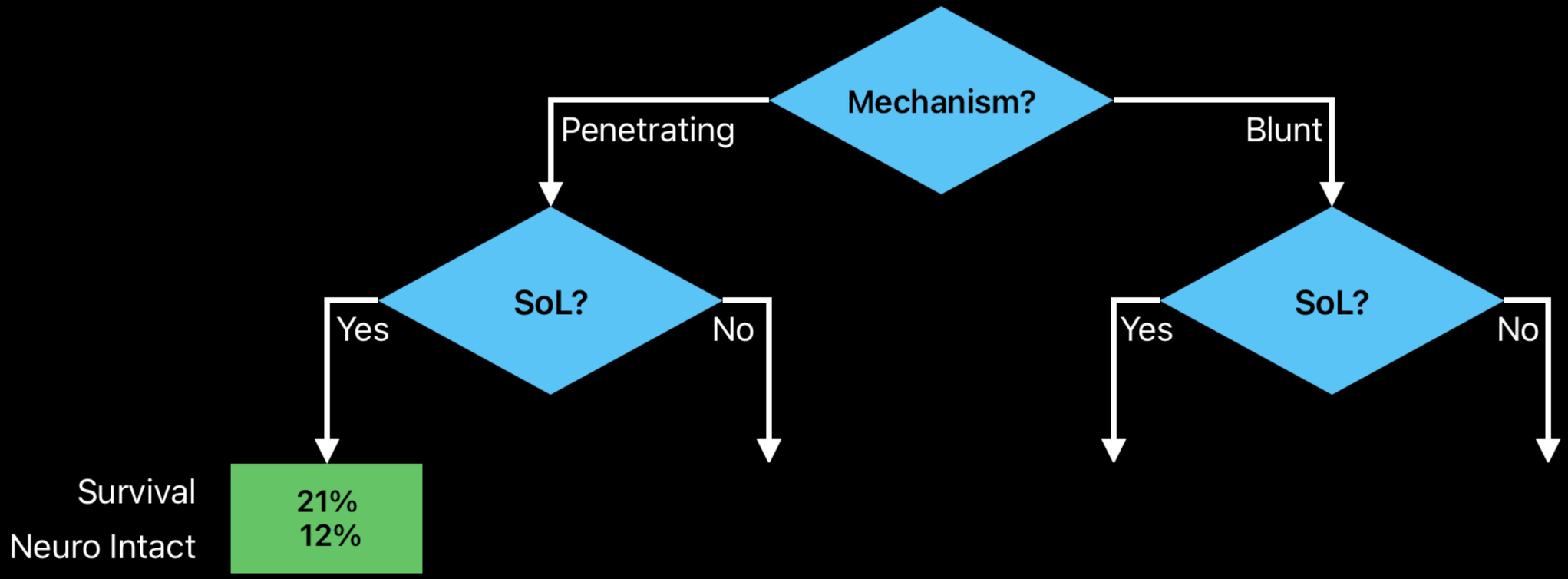


Survival

Neuro Intact

Seamon, et al. 2015

EDT Outcomes



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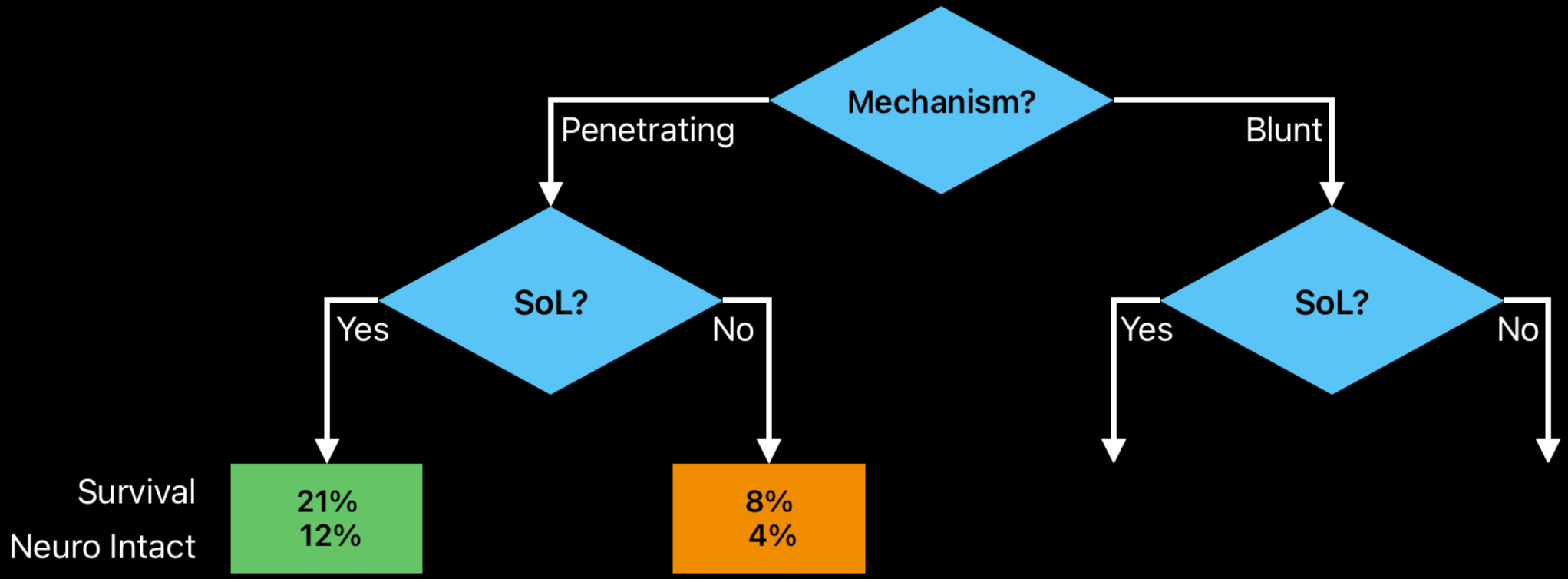

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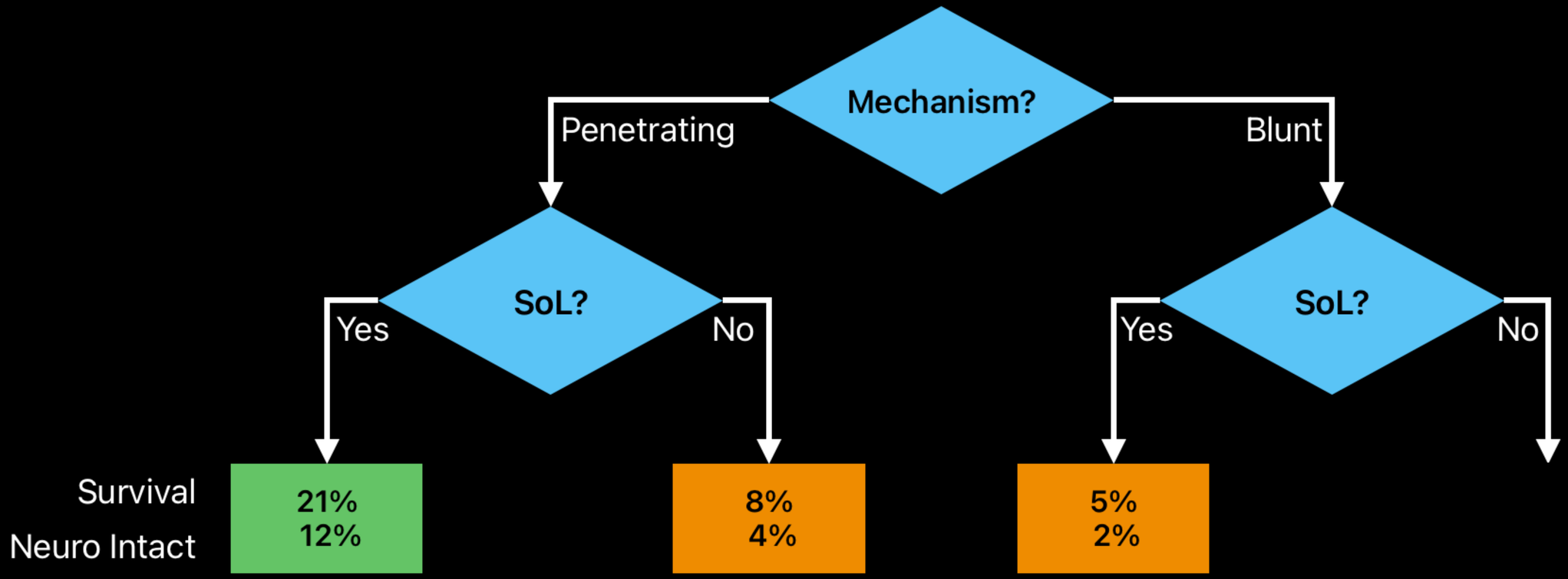

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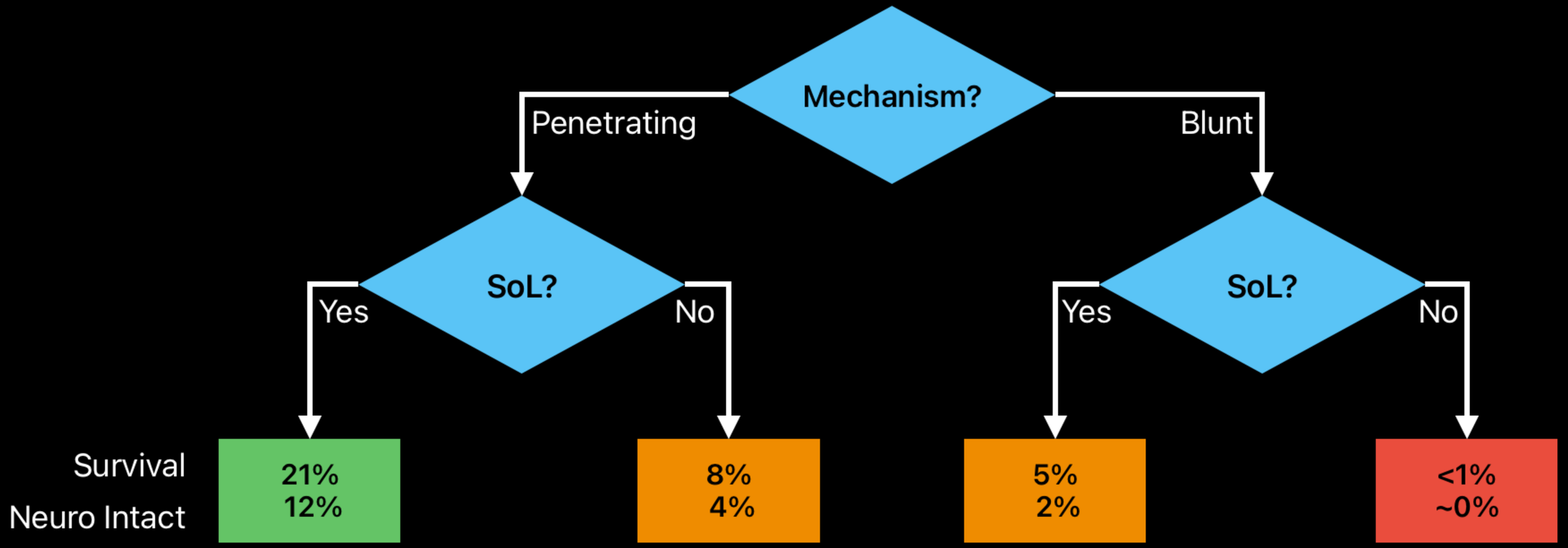
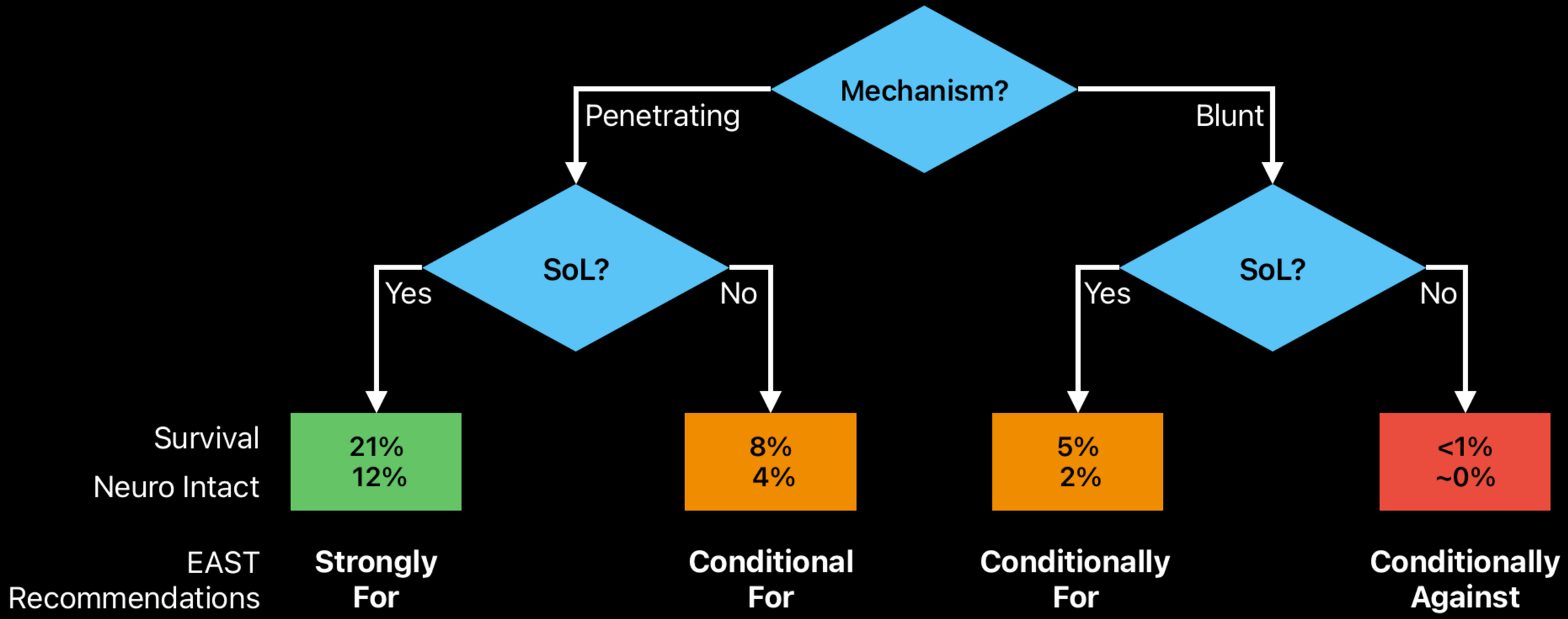


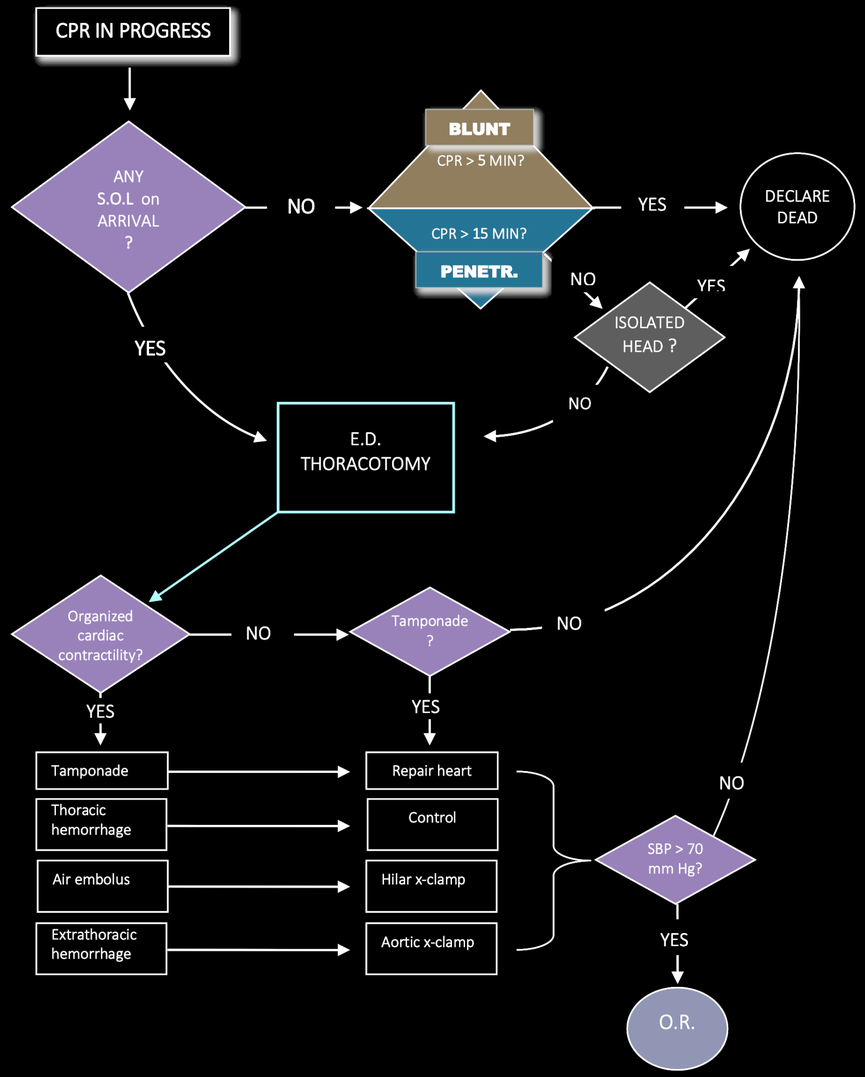
Seamon, et al. 2015

EAST Algorithm



Seamon, et al. 2015

WEST Algorithm



S.O.L (Signs of Life)

1. Detectable blood pressure
2. Electrical cardiac activity *
3. Pupillary reactivity
4. Respiratory or motor effort

* If the only S.O.L. is an idioventricular “escape” rhythm, v-fib, or bradycardia at < 50 BPM: consider pronouncing the patient dead without further resuscitation.

Tacoma Trauma Trust, adapted from Burlew, et al. 2012

How to do it?

Setup: MTP, OR ready, Wide Prep, PPE, suction

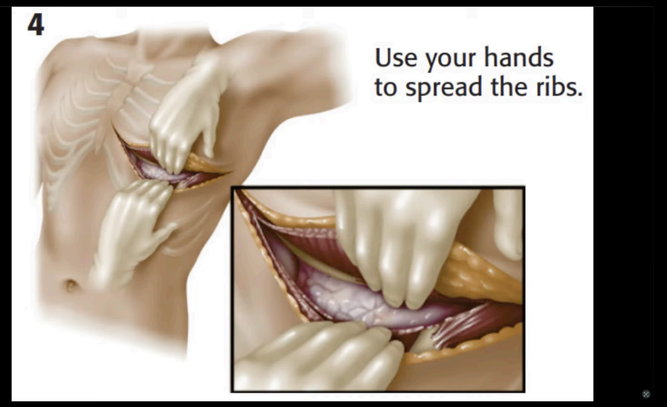
Cut*

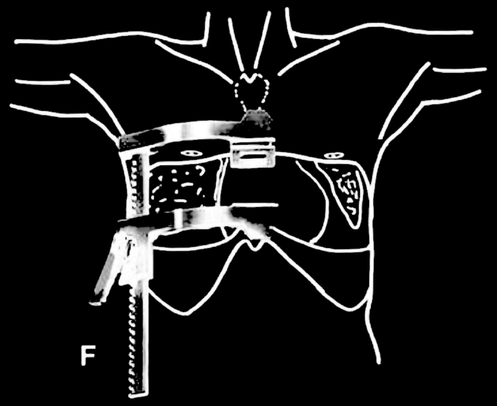
Deliver Heart

Pericardiotomy: Incise pericardium, evacuate clot/blood

Aortic cross-clamp if indicated

Hemorrhage control: Direct pressure, staple/ clamp lung lacs



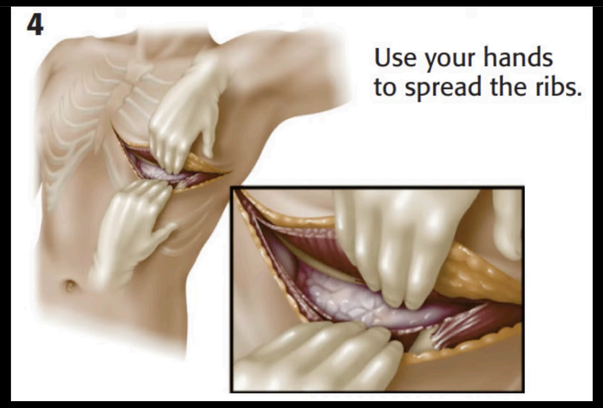


Simms, et al. 2013; Mellick 2024

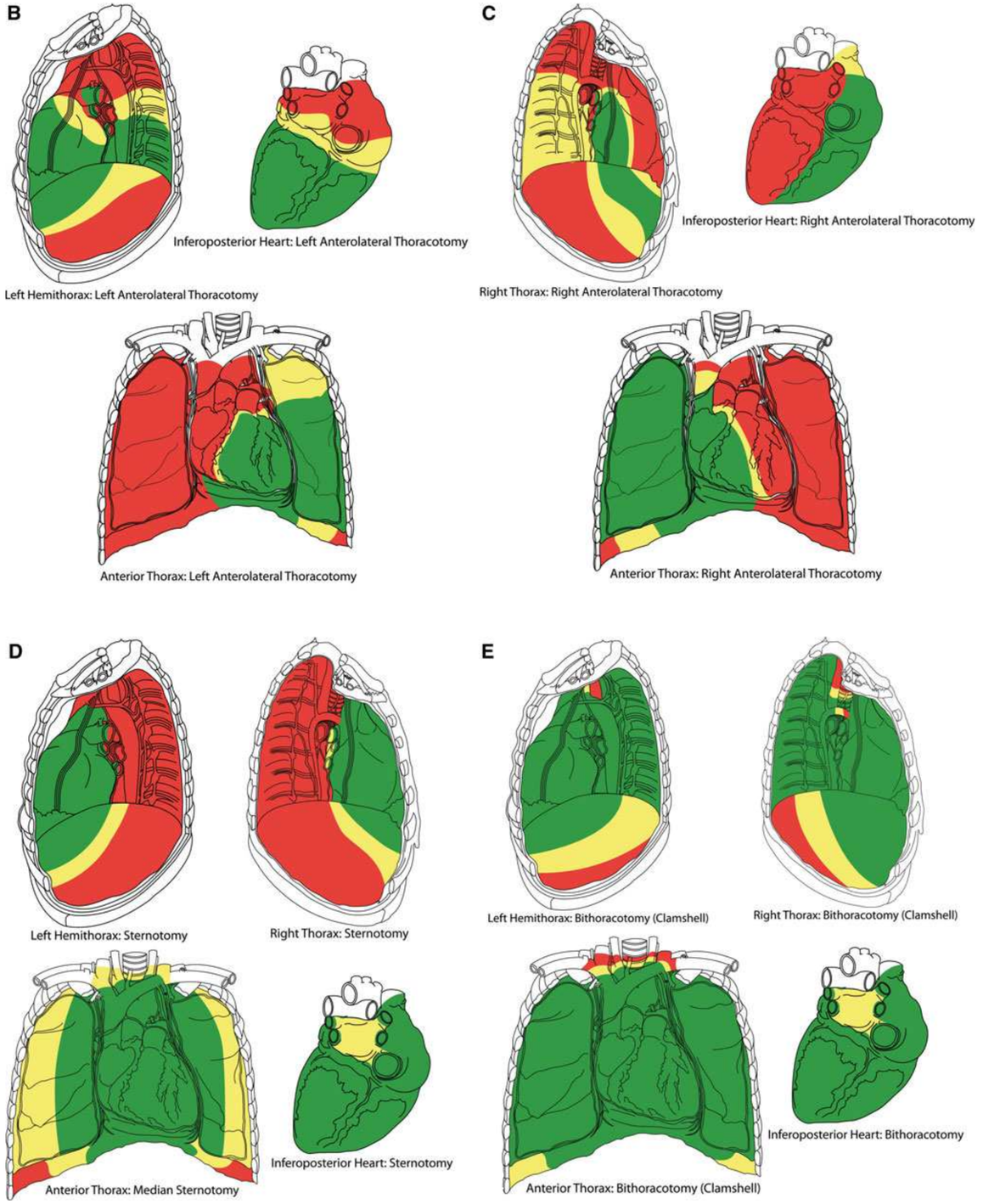
How to cut?

Clamshell Incision Is the Ideal Emergency Thoracotomy Incision

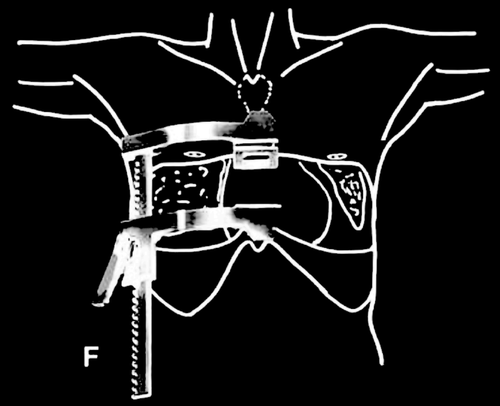
Simms, et al. 2013



L Anterolateral



Clamshell



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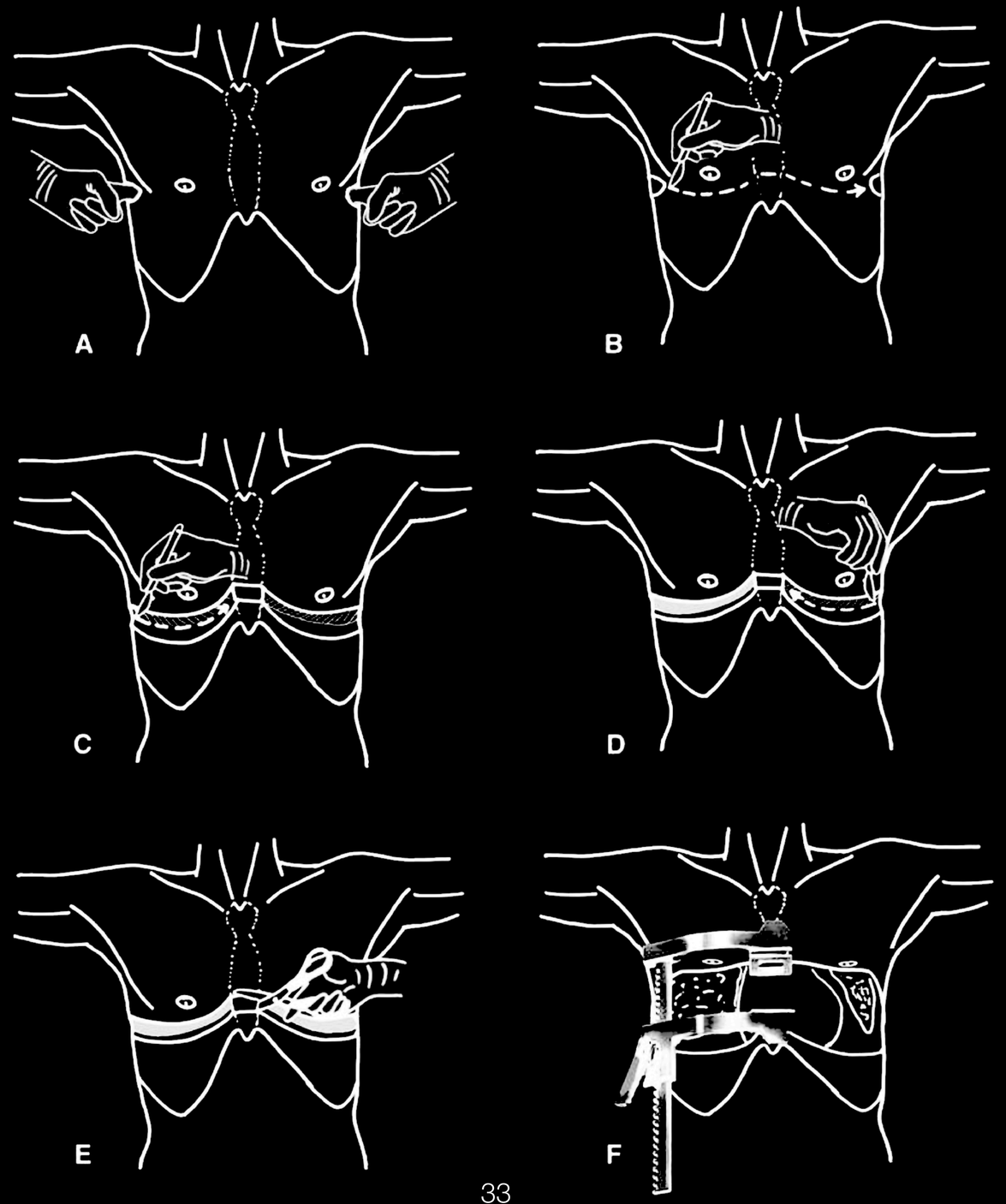
Clamshell

Expand from finger thoracostomies



Simms, et al. 2013

EDT Wrap-Up

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Protocol informed decision

If you need to do it:

- Do it for a reason (e.g., tamponade)
- Do it fast

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Blunt + no SoL + prolonged CPR → don’t do it

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Case 1A: Penetrating, quick arrival, SoL
Probably yes

Case 1B: Blunt, slow arrival, ?SoL
Probably no

Case 2

Case 2: 4F High Speed MVC

Scene
last vehicle in pile-up, appropriately restrained,
other passenger ejected, quick extrication

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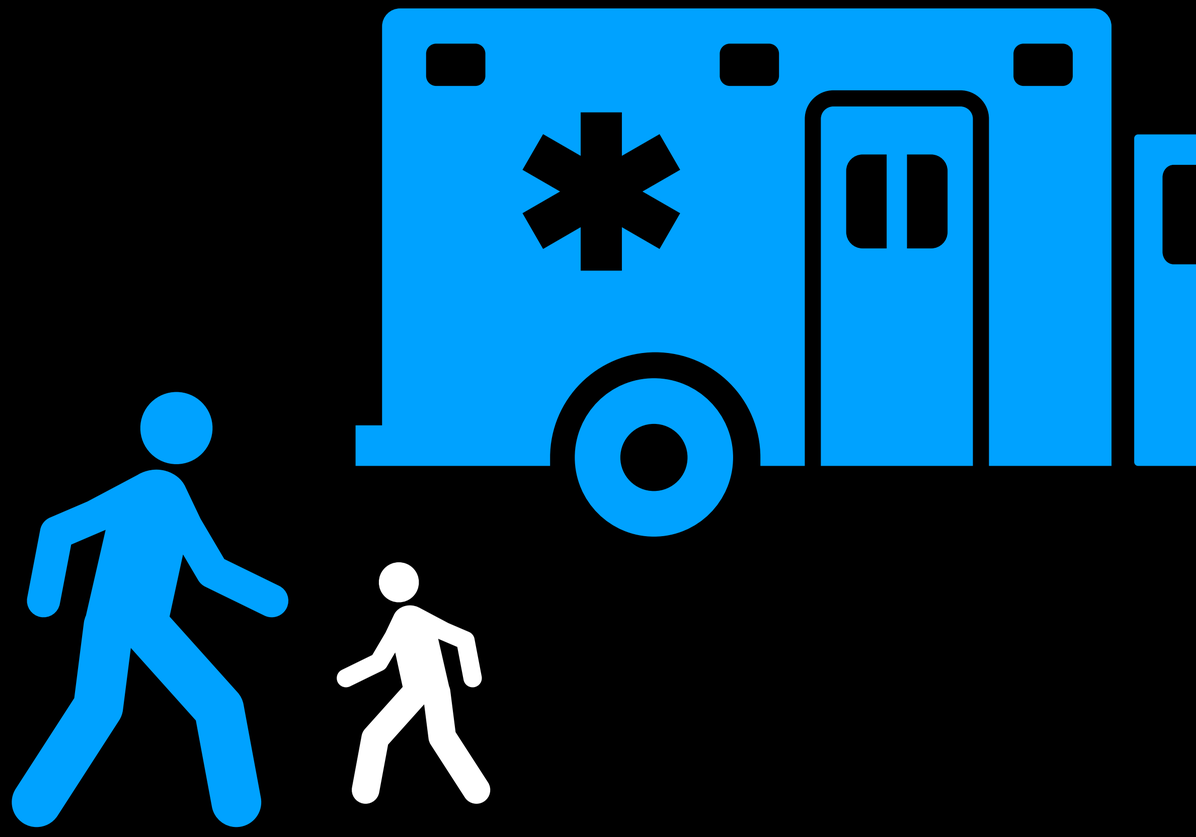

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%: abd pain
2°: no seatbelt sign, abd tender, not peritonitic

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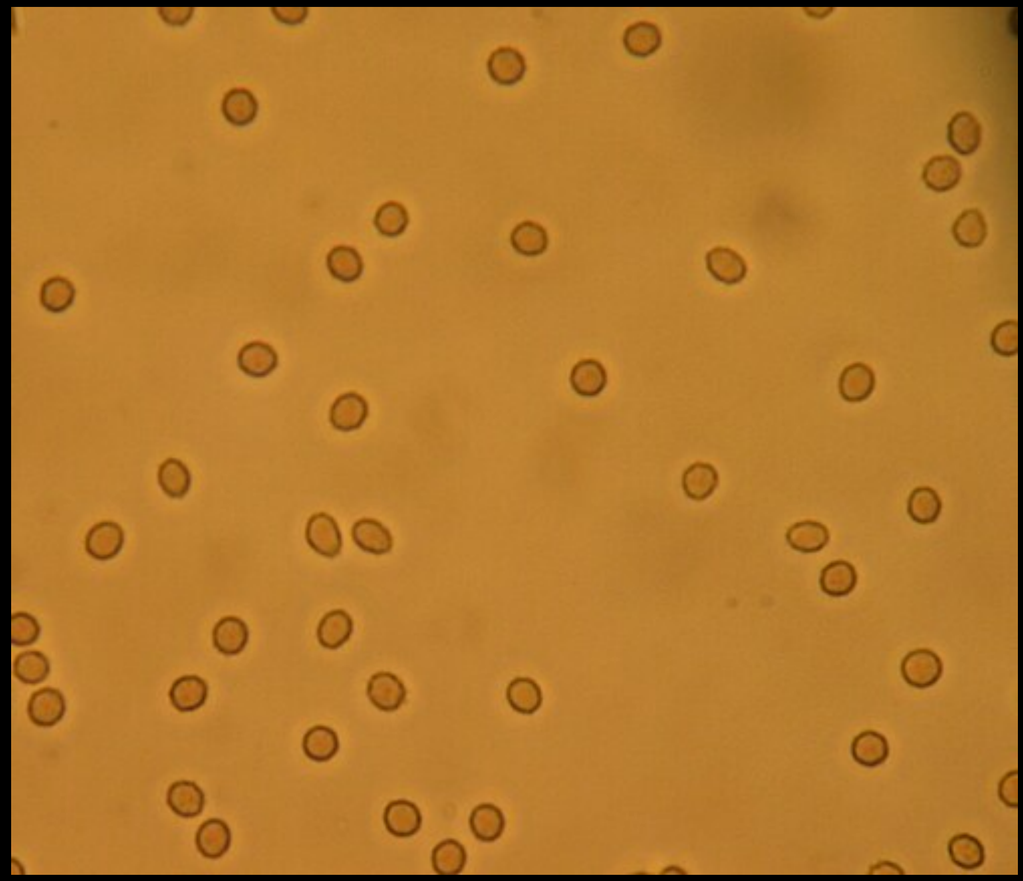

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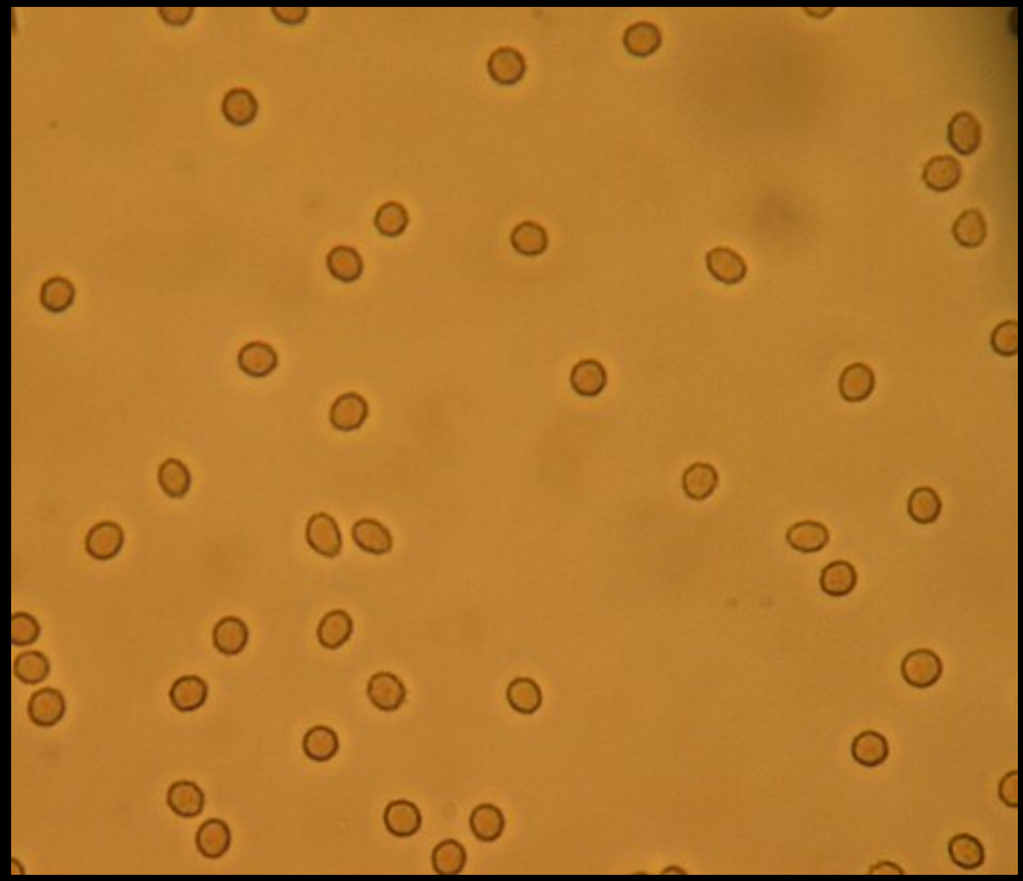
What do we do? CT?



Traumatic Hematuria Evaluation

Renal

Bladder

Urethra

Coccolini, et al. 2019

Traumatic Hematuria Evaluation

Renal → Contrast CT

Bladder

Urethra

Gross hematuria, OR

Microscopic Hematuria with hemodynamic instability, OR

High-risk mechanism/exam

- Rapid deceleration,
- Flank ecchymosis,
- Significant abdominal tenderness

Coccolini, et al. 2019

Traumatic Hematuria Evaluation

Renal → Contrast CT

Bladder → CT Cystography

Urethra

Gross hematuria AND:

Pelvic fracture, OR

High suspicion:
mechanism, pelvic pain, voiding issues

Coccolini, et al. 2019

Traumatic Hematuria Evaluation

Renal → Contrast CT

Bladder → CT Cystography

Urethra → Retrograde Urethrogram

If suspected don’t place foley, image first

- Blood at meatus, OR
- Perineal hematoma, OR
- Inability to pass foley

Coccolini, et al. 2019

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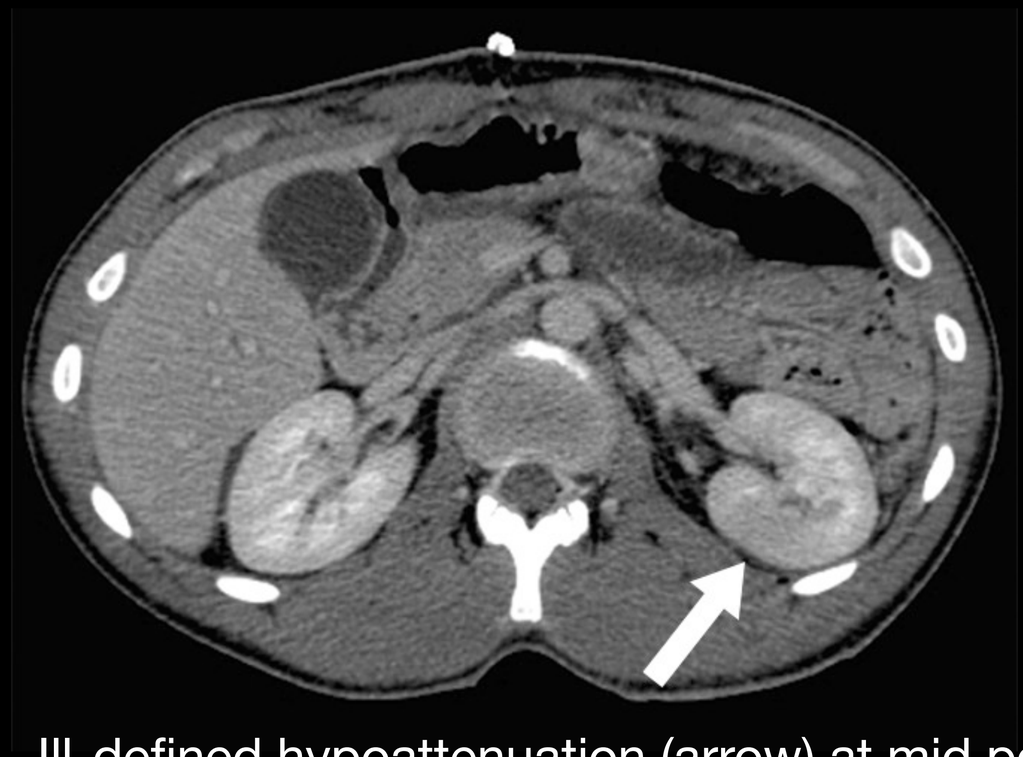
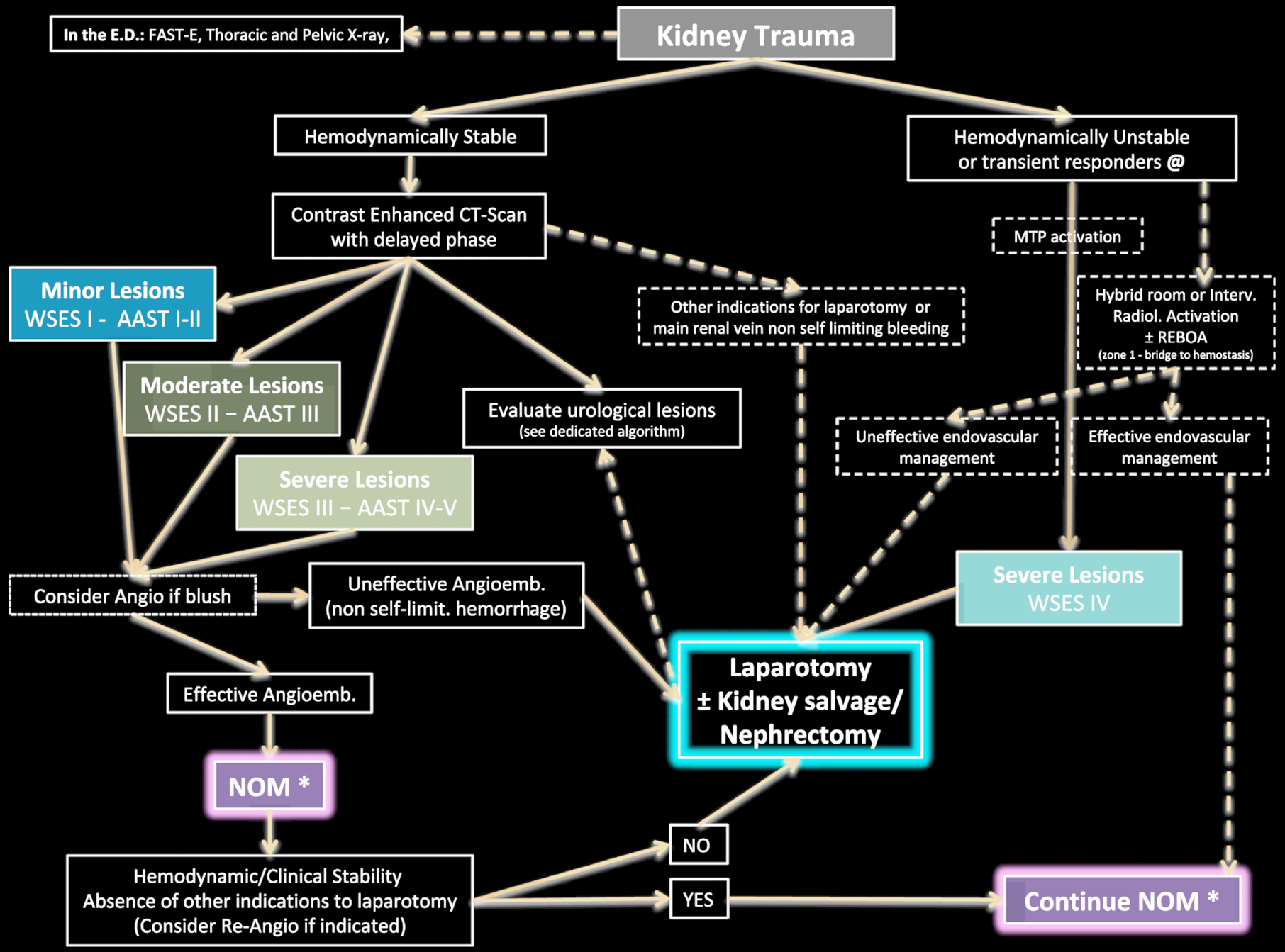


Ill-defined hypoattenuation (arrow) at mid pole of left kidney, consistent with renal contusion

AAST Kidney Injury: Grade 1

Hosein, et al. 2019



Coccolini, et al. 2019

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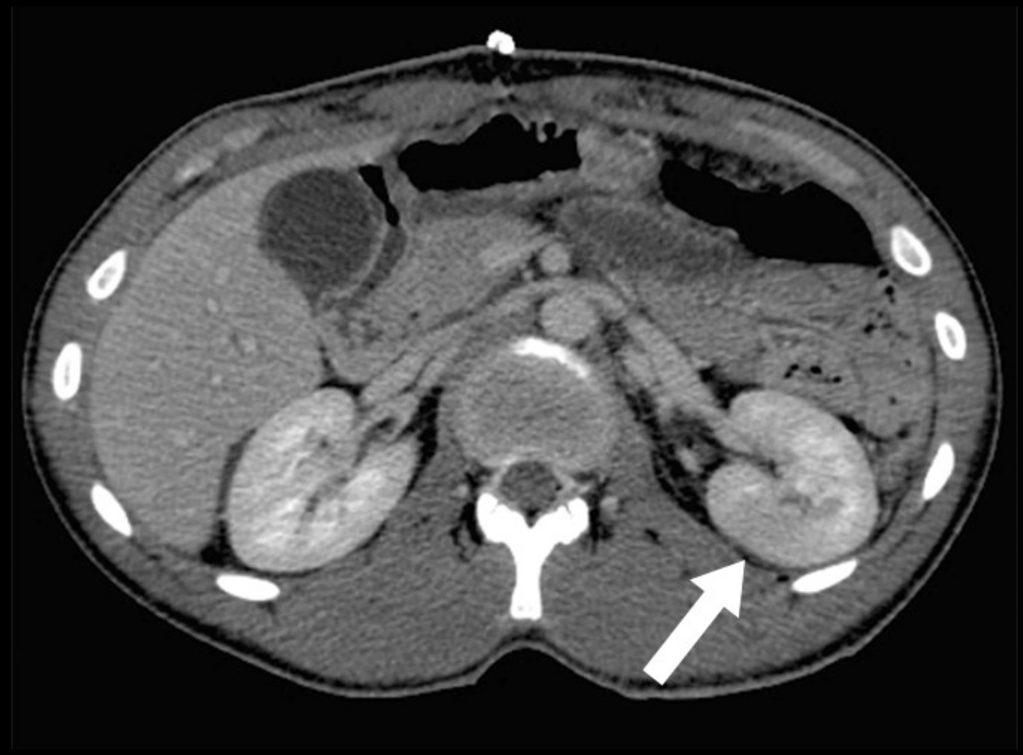


Observed overnight with serial abdominal exams

Traumatic Renal Injuries

Hemodynamically stable: mostly managed nonoperatively

High-grade injuries with ongoing bleeding: angioembolization for kidney-sparing approach

Follow-up:

- pediatric renal trauma guidelines emphasize monitoring,
- follow-up BP checks to detect post-traumatic HTN

Hagedorn, et al. 2019

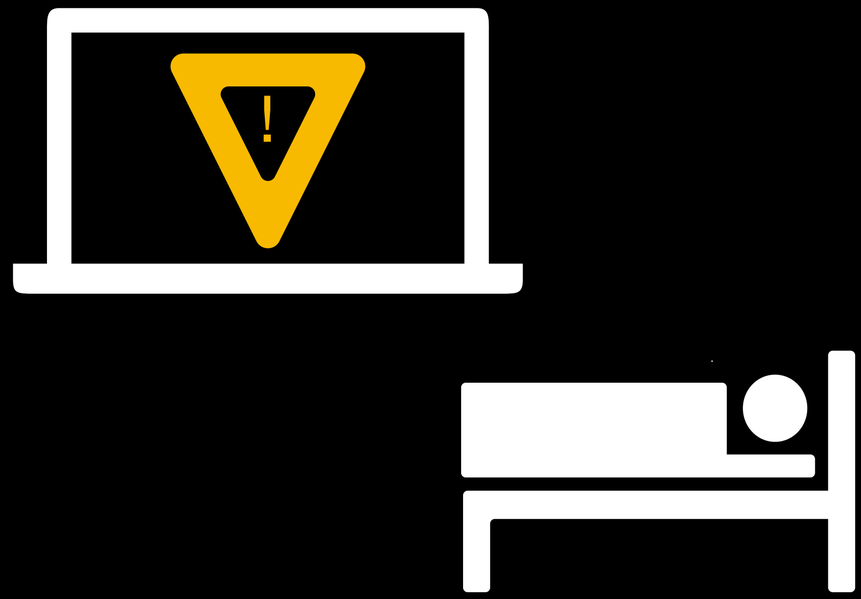
Case 3

Case 3: 60M High Speed MVC t-3

F4/4 (at Michigan)
MVC, +FAST, s/p ex-lap splenectomy 3 days ago

2000
A little more confused, SBPs 100s
You start fluid resuscitation and abx
Pressures respond

Page @0300
Epic Sepsis AI Model sends an alert



Evaluation of predictive AI models

First, some definitions

Artificial Intelligence (AI): *perceiving, synthesizing, and inferring information* demonstrated by machines

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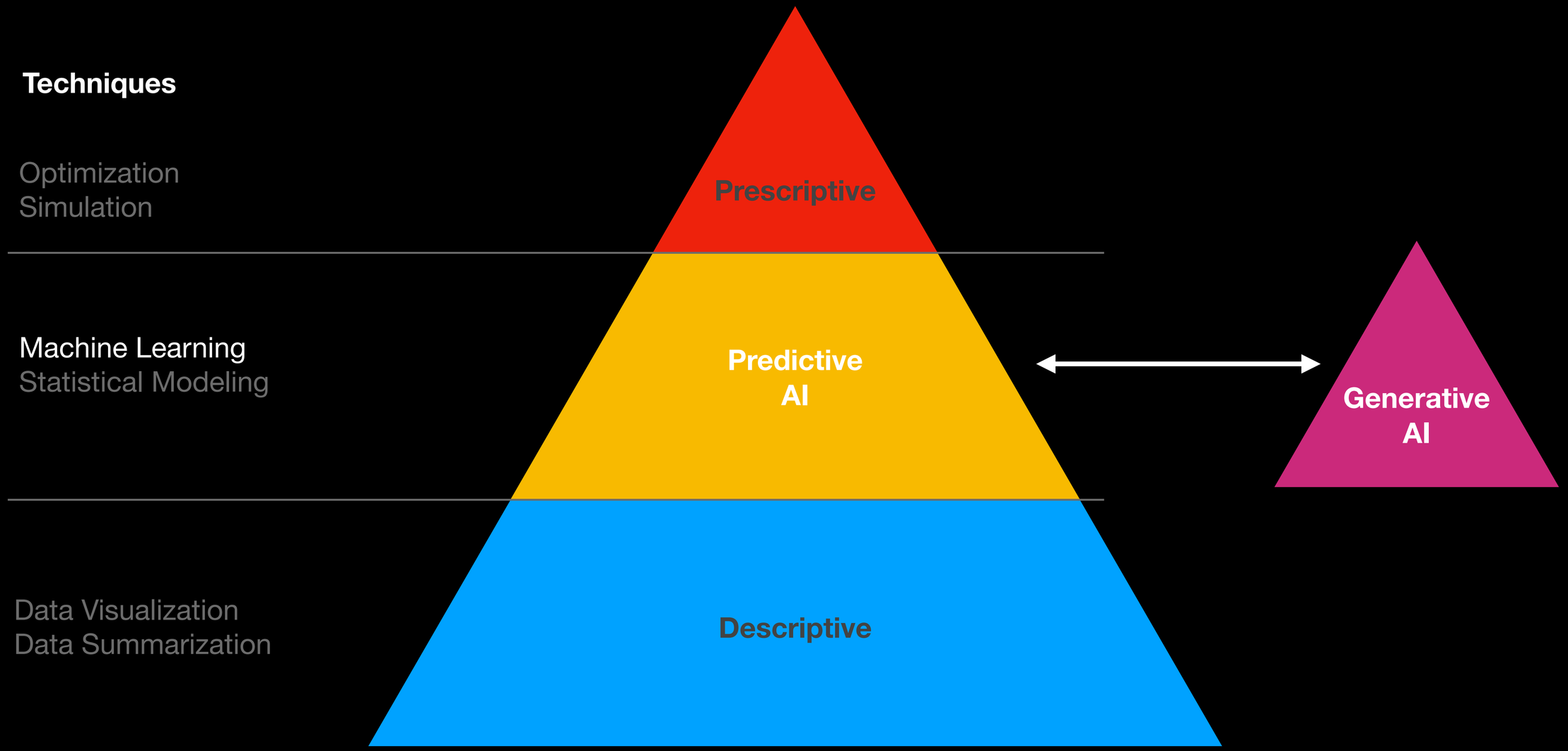
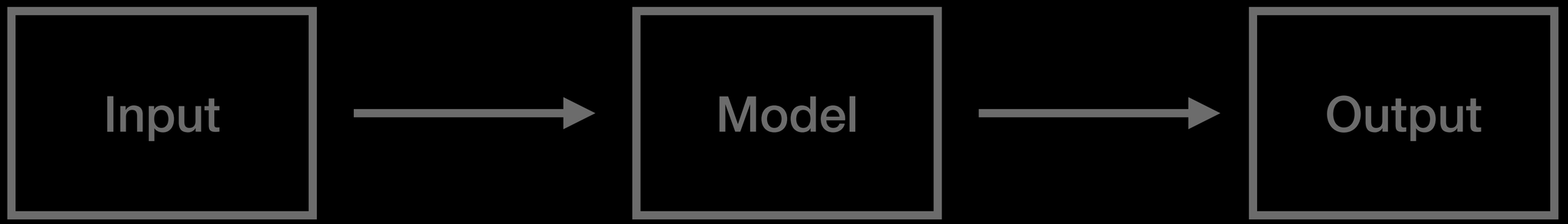
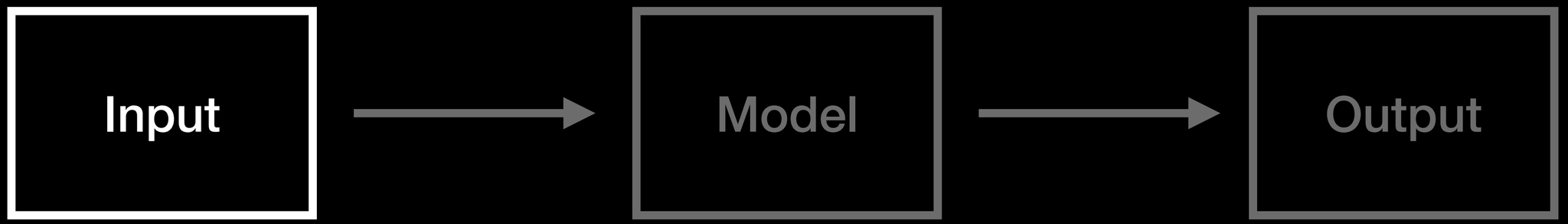
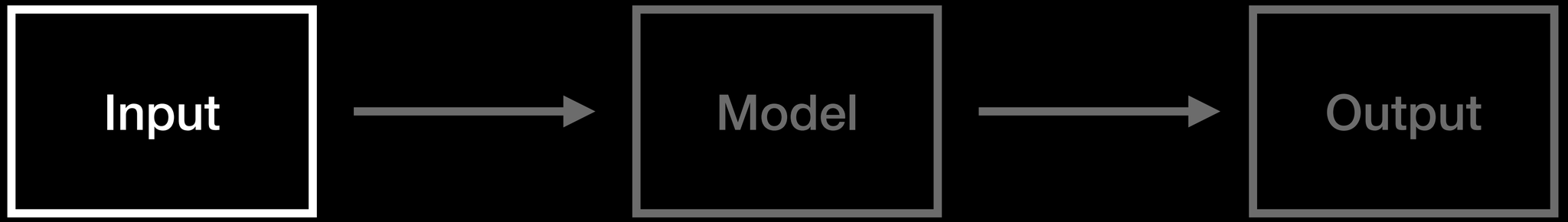
Generative AI: given some information can we *create* some additional or other type information

Connection between AI types

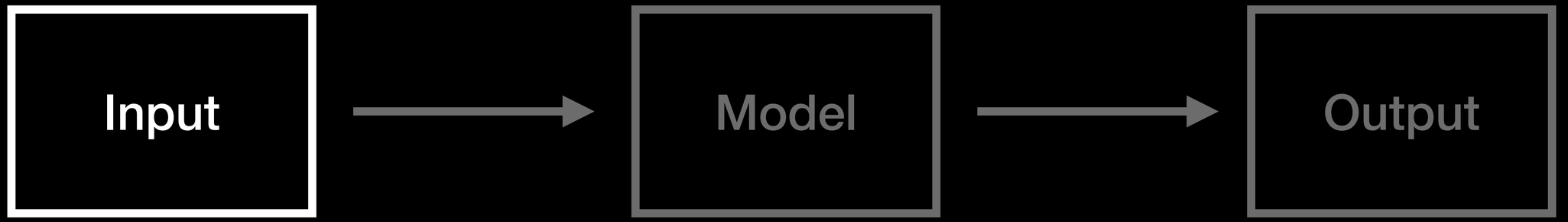



Input
Model
Output


Input
Model
Output

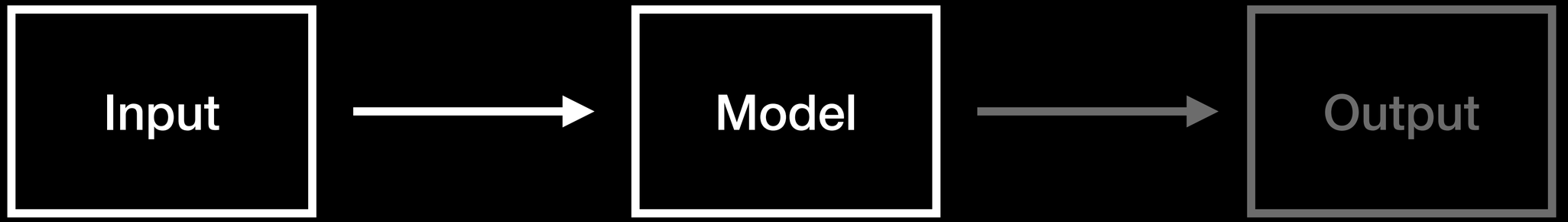


what we know



what we know

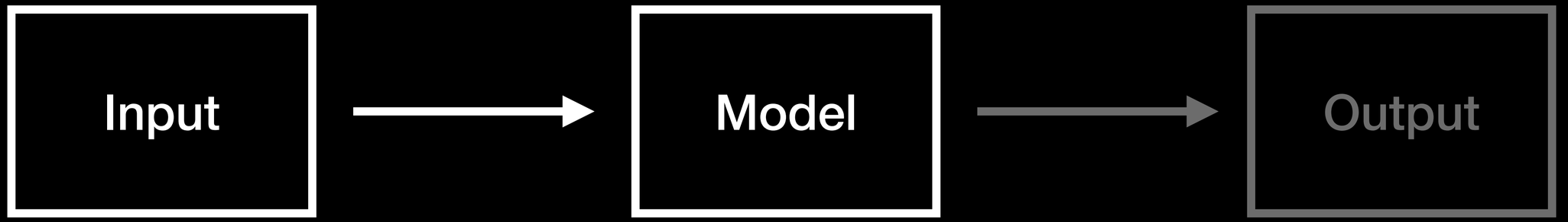
Age
Heart Rate
Comorbidities
Medications



what we know

Age
Heart Rate
Comorbidities
Medications

Rules
ML Model
AI Algorithm



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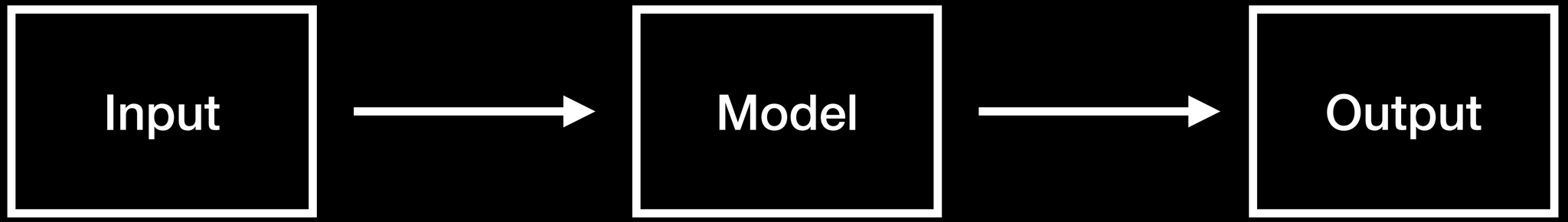
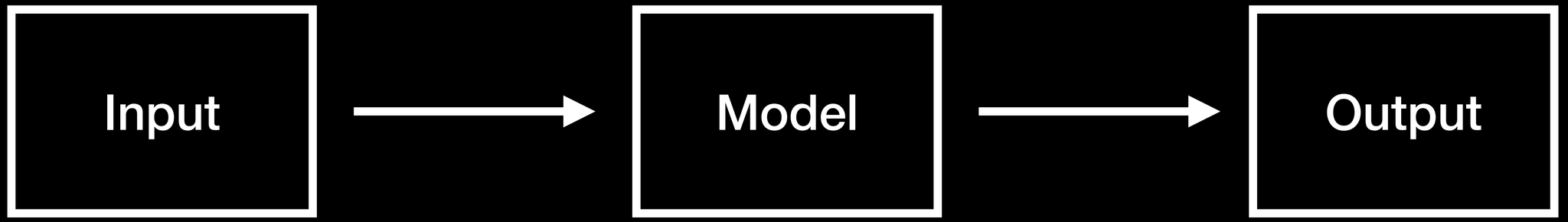


what we know

Age
Heart Rate
Comorbidities
Medications

Rules
ML Model
AI Algorithm

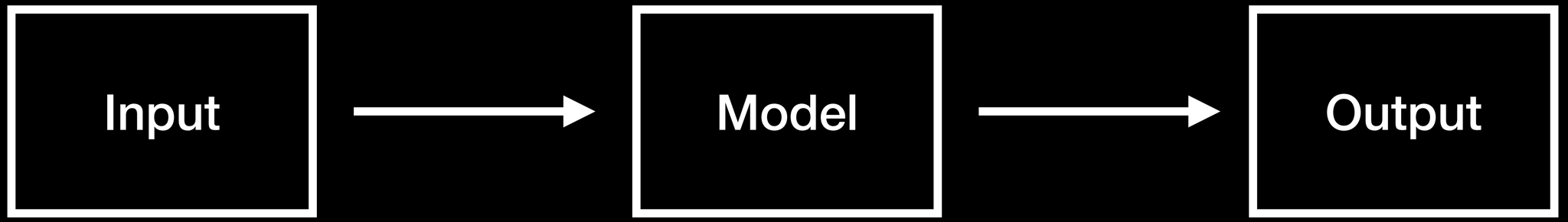


what we know

Age
Heart Rate
Comorbidities
Medications

prediction

Rules
ML Model
AI Algorithm



what we know

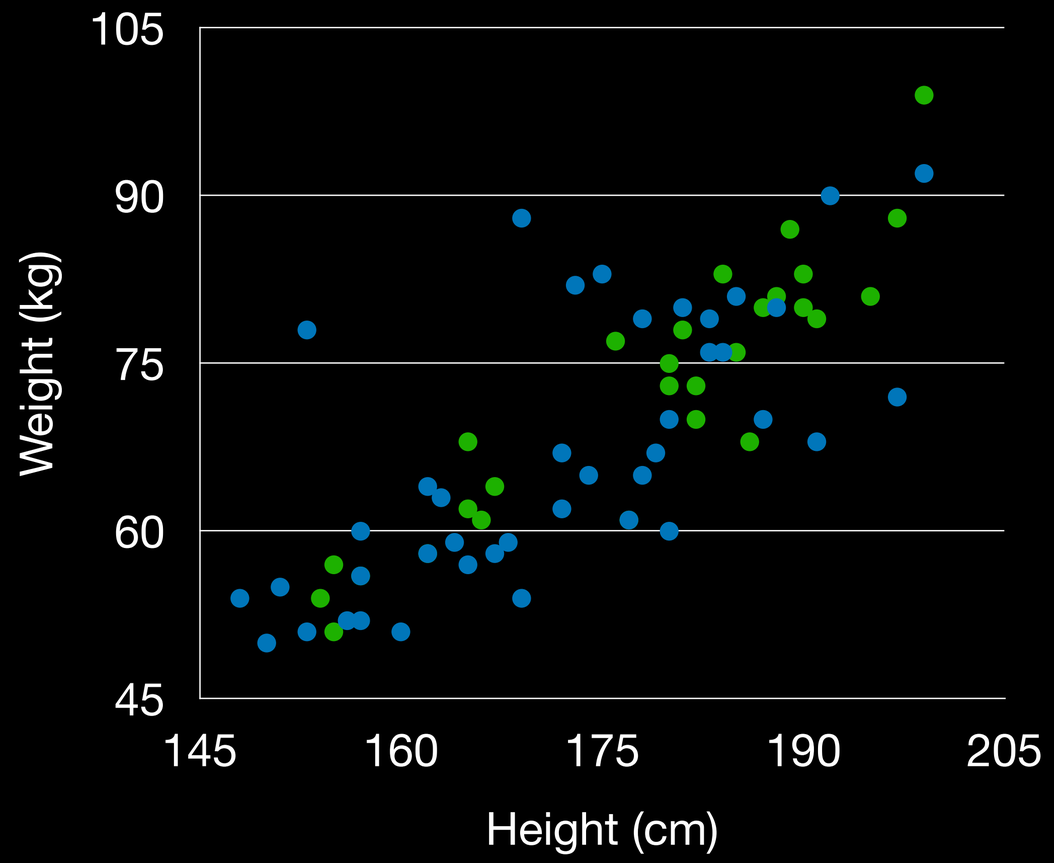
Age
Heart Rate
Comorbidities
Medications

prediction

Risk of Diabetes
Length of Stay

How do we make models?

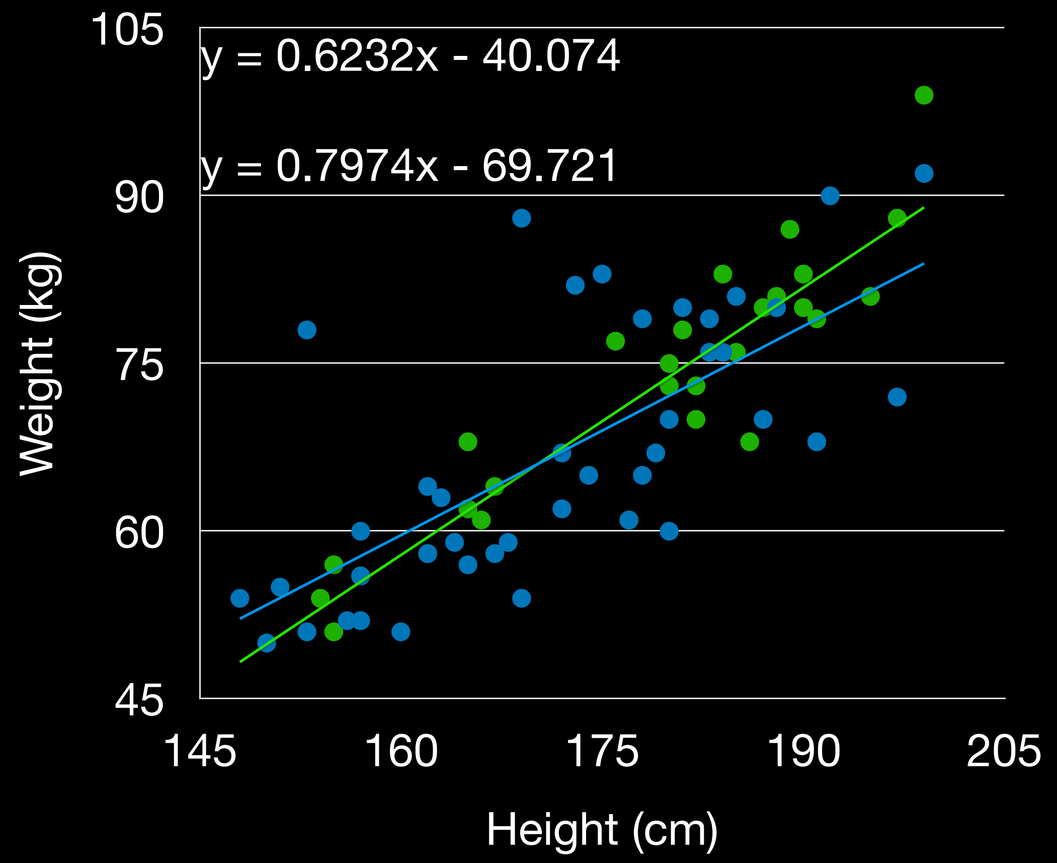
How do we make models?



Have lots of data?

Have lots of knowledge?

How do we build the model?



Data Driven

```
IF patient.sex = Female:
      IF patient.height < 160cm:
            THEN predicted_weight = 55kg
      …
IF patient.sex = Male:
      …
      IF patient.height > 195cm:
            THEN predicted_weight = 90kg
```

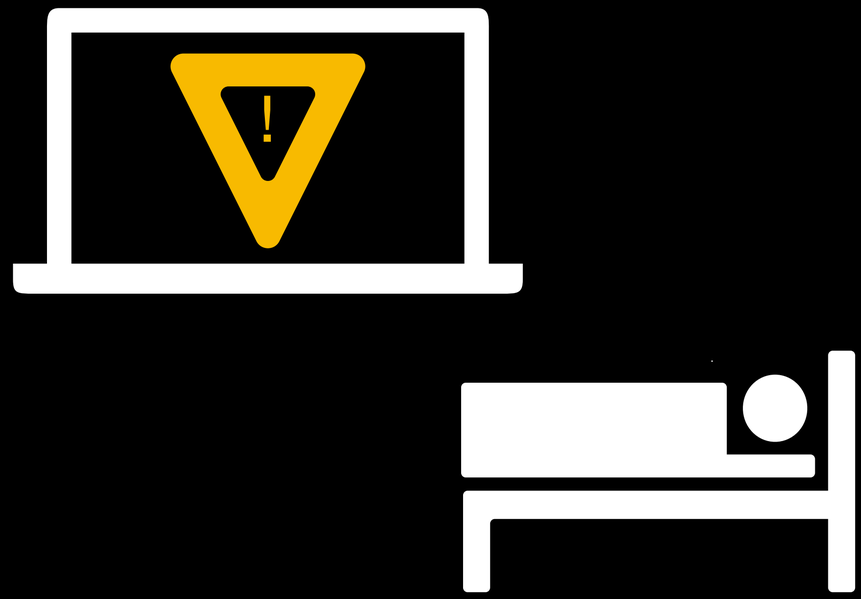
Derived from Theory/Rule

Case 3: 60M High Speed MVC t-3

F4/4 (at Michigan)
MVC, +FAST, s/p ex-lap splenectomy 3 days ago

2000
A little more confused, SBPs 100s
You start fluid resuscitation and abx
Pressures respond

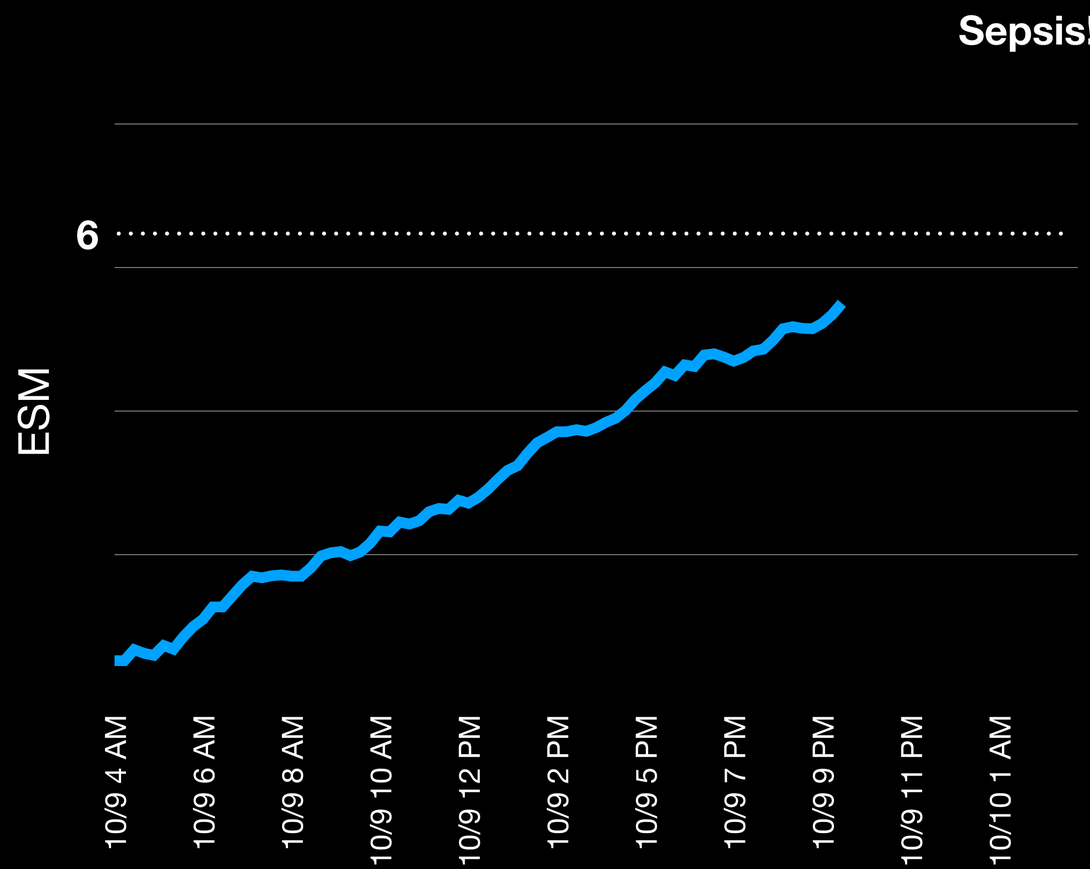
Page @0300
Epic Sepsis AI Model sends an alert



How does the Epic Sepsis Model work?

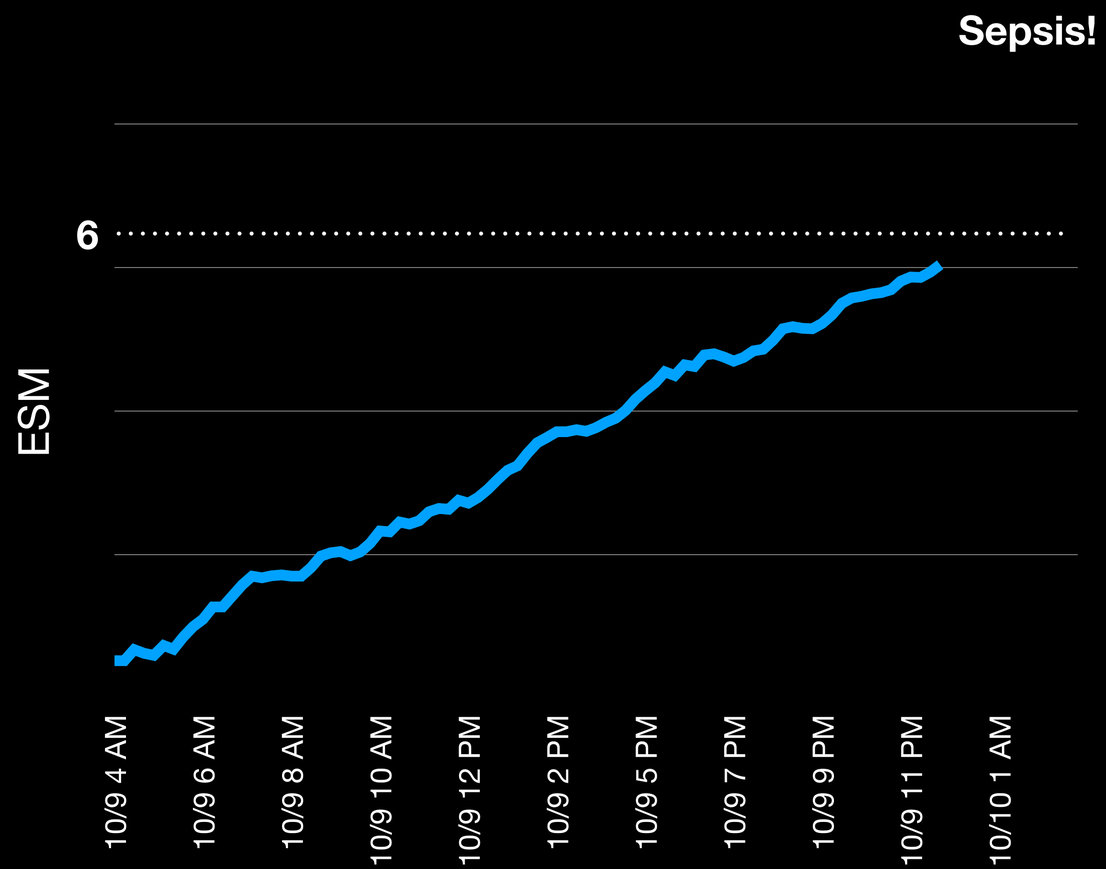
What does it take as inputs? Outputs?
How often does it produce scores for patients?

Epic Sepsis Model



Wong, et al. 2021

Epic Sepsis Model



Wong, et al. 2021

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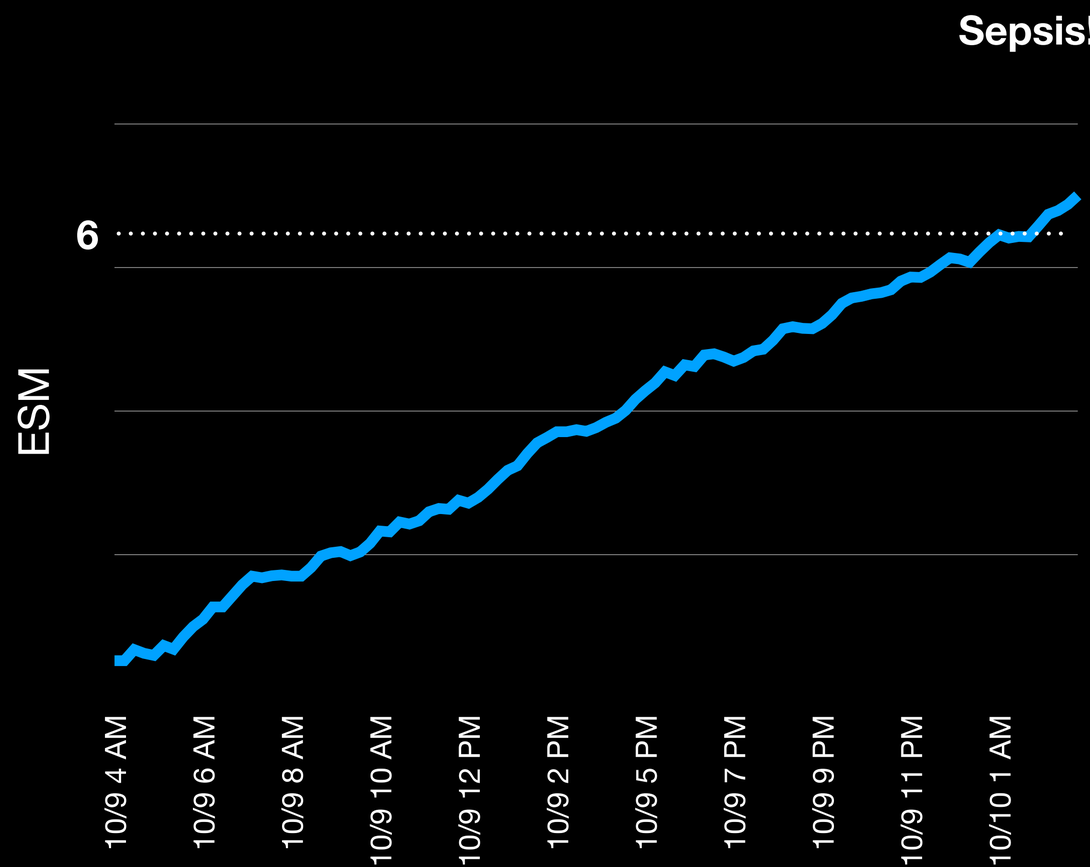

Wong, et al. 2021

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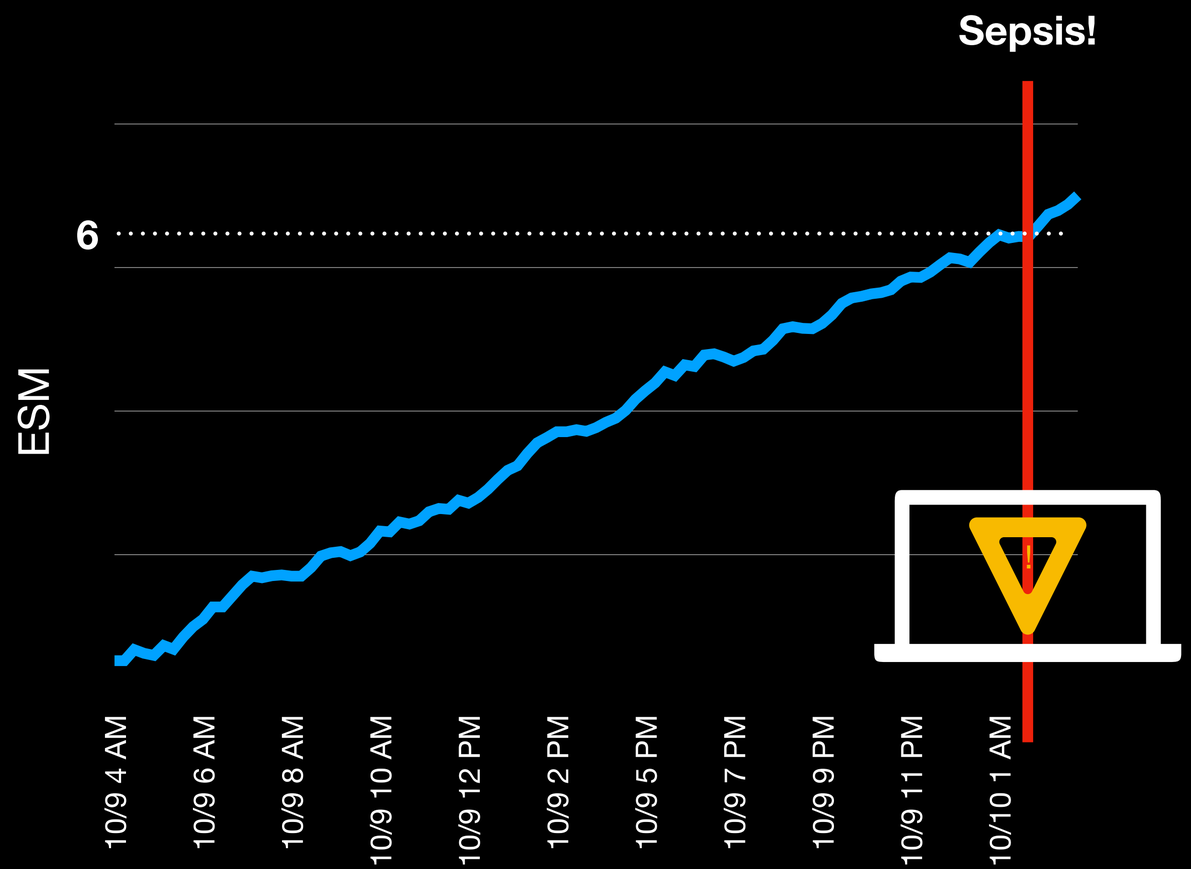

Wong, et al. 2021

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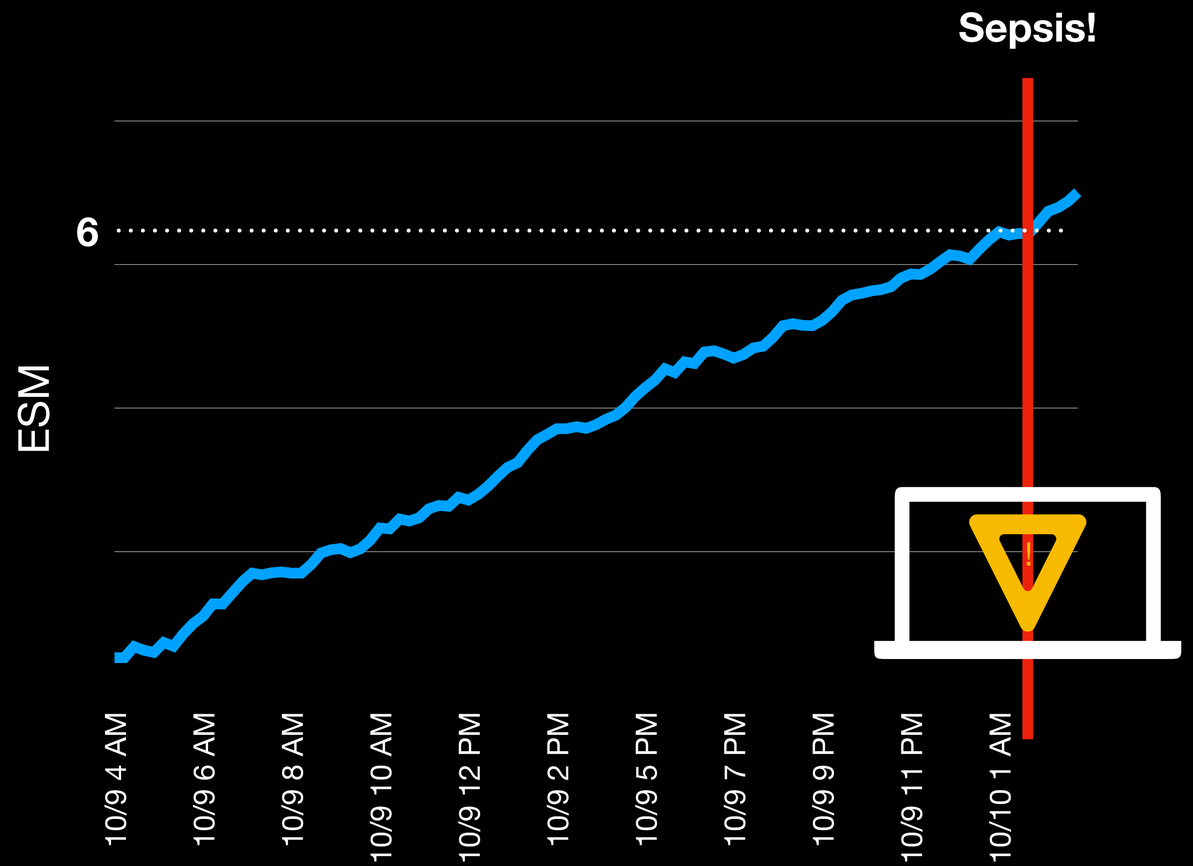


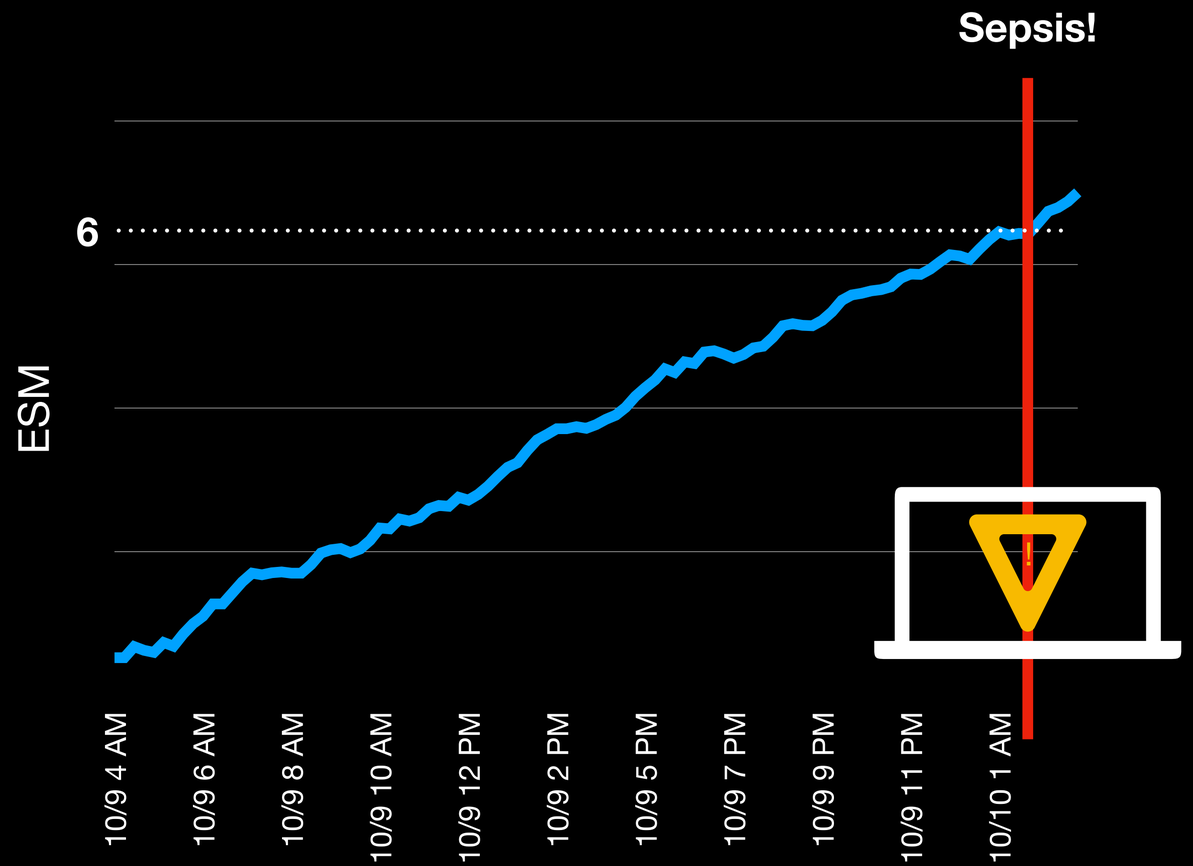
Development

Inputs: vital signs, medication orders, lab values, comorbidities, and demographic information.

Outputs: Sepsis flag, based on ICD-9 code
Timing: 6hrs prior to clinical intervention

Wong, et al. 2021

Epic Sepsis Model



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Outputs: Sepsis flag, based on ICD-9 code
Timing: 6hrs prior to clinical intervention

Implementation

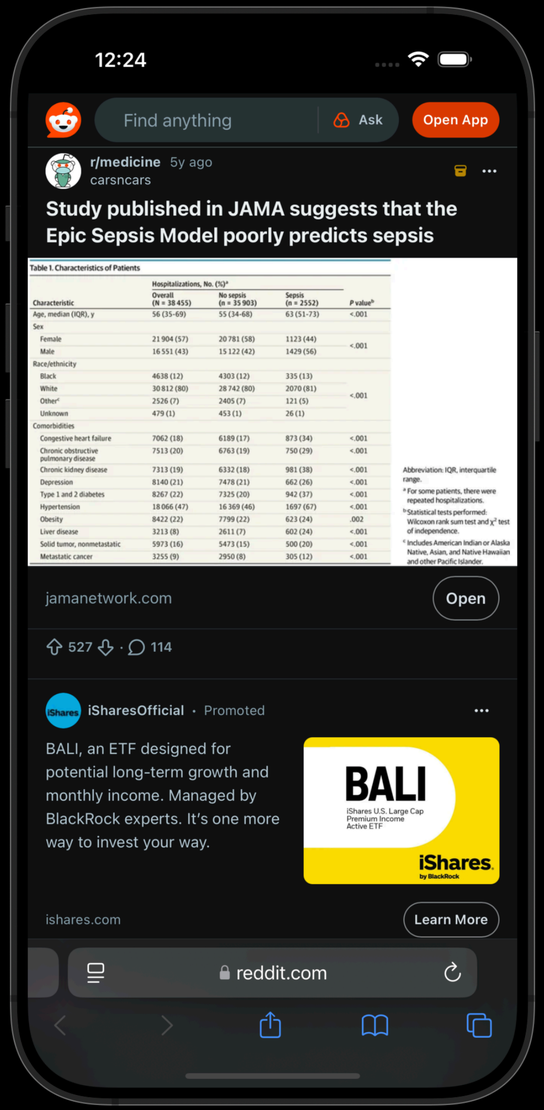
Runs every 15 minutes on all ED & admitted patient

Expected AUROC performance ~ 0.8

Wong, et al. 2021

How do you evaluate this model?

Statistics



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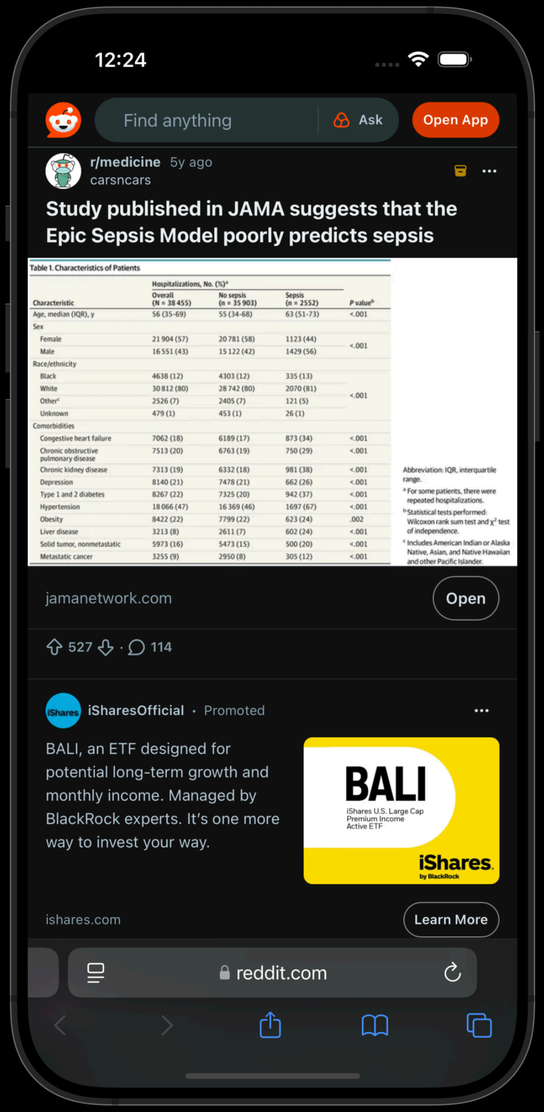
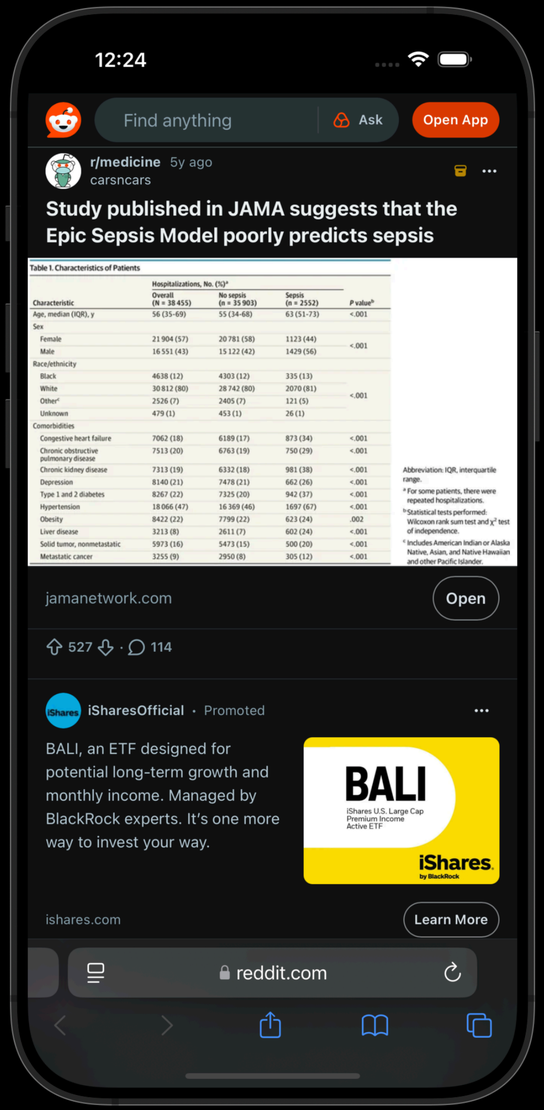


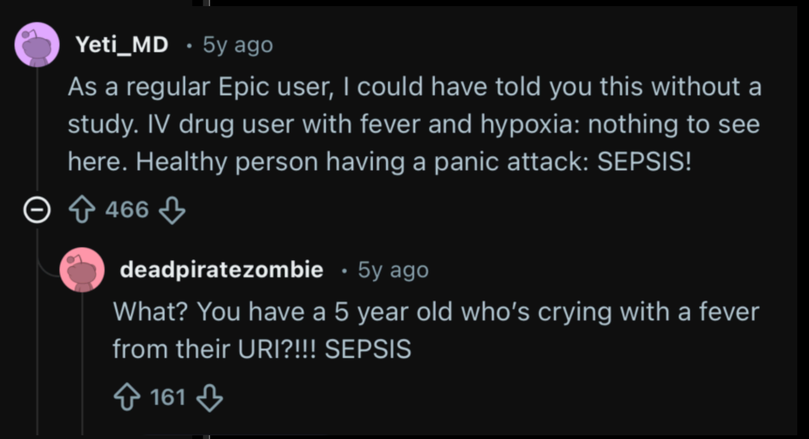
Vibes

How do you evaluate this model?

Statistics



Vibes



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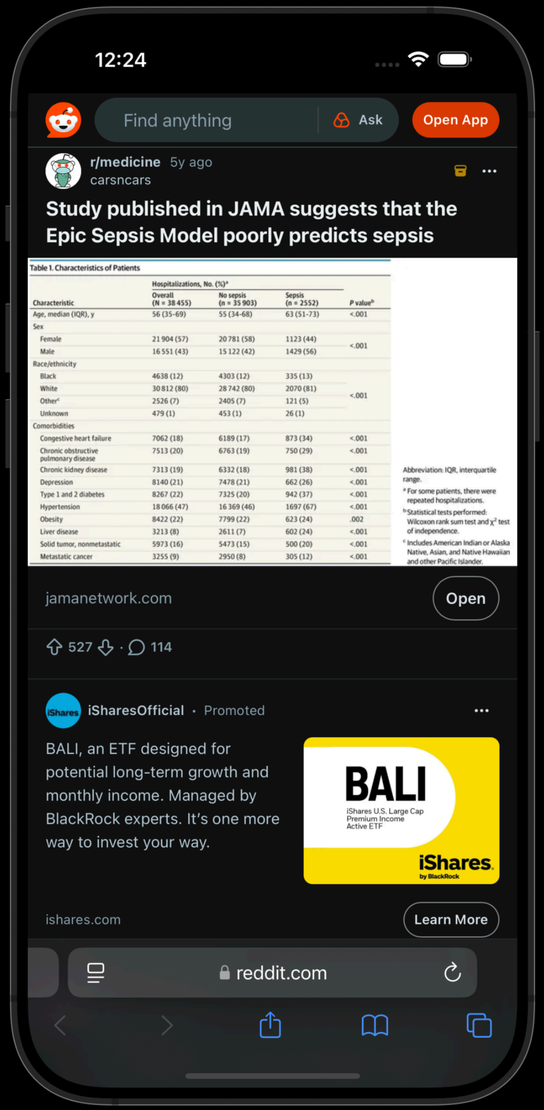


	Patient 1
10/9 4 AM	0.93
10/9 4 AM	0.93
10/9 4 AM	
10/9 4 AM	
10/9 5 AM	
10/9 5 AM	
10/9 5 AM	
10/9 6 AM	
10/9 6 AM	
10/9 6 AM	
10/9 6 AM	
10/9 7 AM	

	Patient k
10/9 4 AM	1.35
10/9 4 AM	2.11
10/9 4 AM	
10/9 4 AM	
10/9 5 AM	
10/9 5 AM	
10/9 5 AM	
10/9 6 AM	
10/9 6 AM	
10/9 6 AM	
10/9 6 AM	
10/9 6 AM	
10/9 6 AM	
10/9 6 AM	
10/9 7 AM	

	Patient n
10/9 4 AM	2.97
10/9 4 AM	1.8
10/9 4 AM	1.2
10/9 4 AM	1.11
10/9 5 AM	1.06
10/9 5 AM	1.3
10/9 5 AM	1.21
10/9 5 AM	1.51
10/9 6 AM	1.76
10/9 6 AM	1.94
10/9 6 AM	2.24
10/9 6 AM	2.24
10/9 6 AM	2.51
10/9 7 AM	2.78

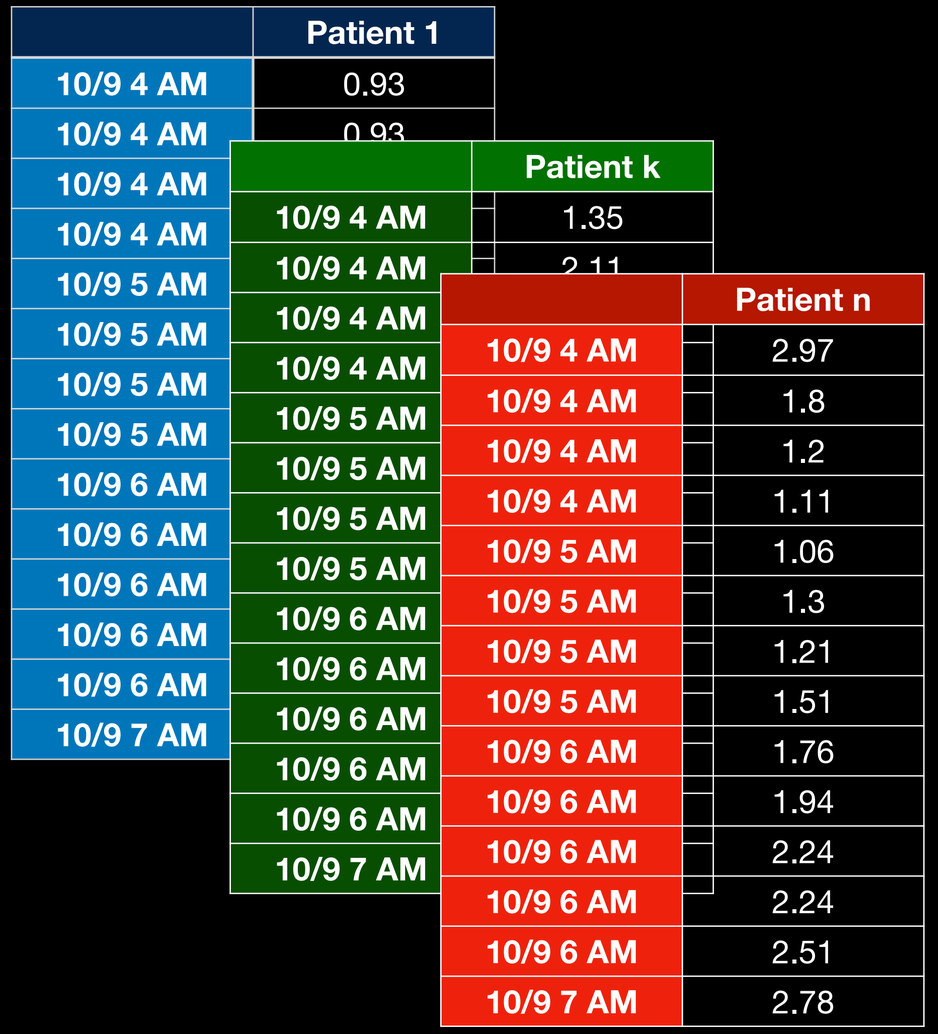
How do you evaluate this model?

What outcome?

How to handle multiple scores per patient?

How about workflow impact?

Try to capture clinical utility (i.e. vibes)



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10/9 4 AM	0.93
10/9 4 AM	0.93
10/9 4 AM	
10/9 4 AM	
10/9 5 AM	
10/9 5 AM	
10/9 5 AM	
10/9 5 AM	
10/9 6 AM	
10/9 6 AM	
10/9 6 AM	
10/9 6 AM	
10/9 6 AM	
10/9 7 AM	

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10/9 5 AM	
10/9 5 AM	
10/9 5 AM	
10/9 6 AM	
10/9 6 AM	
10/9 6 AM	
10/9 6 AM	
10/9 6 AM	
10/9 7 AM	

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External Validation of a Widely Implemented Proprietary Sepsis Prediction Model in Hospitalized Patients

Retrospective cohort study (external validation)

27,697 adult patients admitted to Michigan Medicine in 2019 → 38,455 hospital encounters

ESM identified 183 of 2552 encounters with sepsis (7%) who did not receive timely abx

Did not identify 1709 patients with sepsis (67%)

Alerts for 6,971 encounters (18%)

Table 1. Characteristics of Patients

Characteristic	Hospitalizations, No. (%)[a] Overall (N = 38 455)	No sepsis (n = 35 903)	Sepsis (n = 2552)	*P* value[b]
Age, median (IQR), y	56 (35-69)	55 (34-68)	63 (51-73)	<.001
Sex				
Female	21 904 (57)	20 781 (58)	1123 (44)	<.001
Male	16 551 (43)	15 122 (42)	1429 (56)	
Race/ethnicity				
Black	4638 (12)	4303 (12)	335 (13)	<.001
White	30 812 (80)	28 742 (80)	2070 (81)	
Other[c]	2526 (7)	2405 (7)	121 (5)	
Unknown	479 (1)	453 (1)	26 (1)	
Comorbidities				
Congestive heart failure	7062 (18)	6189 (17)	873 (34)	<.001
Chronic obstructive pulmonary disease	7513 (20)	6763 (19)	750 (29)	<.001
Chronic kidney disease	7313 (19)	6332 (18)	981 (38)	<.001
Depression	8140 (21)	7478 (21)	662 (26)	<.001
Type 1 and 2 diabetes	8267 (22)	7325 (20)	942 (37)	<.001
Hypertension	18 066 (47)	16 369 (46)	1697 (67)	<.001
Obesity	8422 (22)	7799 (22)	623 (24)	.002
Liver disease	3213 (8)	2611 (7)	602 (24)	<.001
Solid tumor, nonmetastatic	5973 (16)	5473 (15)	500 (20)	<.001
Metastatic cancer	3255 (9)	2950 (8)	305 (12)	<.001

Wong, et al. 2021

Sepsis Outcome Definition

Operational outcome

Health Catalyst (vendor) definition of sepsis that we use to keep track of Michigan's sepsis performance

Definition of Sepsis and Timing of Onset

Sepsis was defined based on meeting 1 of 2 criteria: (1) the Centers for Disease Control and Prevention clinical surveillance definition[18-20] or (2) an *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision* diagnosis of sepsis accompanied by meeting 2 criteria for systemic inflammatory response syndrome and 1 Centers for Medicare & Medicaid Services criterion for organ dysfunction within 6 hours of one another (eMethods in the Supplement).

Wong, et al. 2021

ESM Performance

Model performance	Hospitalization	Time horizons			
		24 h	12 h	8 h	4 h
Outcome incidence, %	6.6	0.43	0.29	0.22	0.14
Area under the receiver operating characteristic curve (95% CI)	0.63 (0.62-0.64)	0.72 (0.72-0.72)	0.73 (0.73-0.74)	0.74 (0.74-0.75)	0.76 (0.75-0.76)
Positive predictive value (ESM score ≥6), %	12	2.4	1.7	1.4	0.92
No. needed to evaluate (ESM score ≥6)[a]	8	42	59	73	109

Abbreviation: ESM, Epic Sepsis Model.

[a] The number needed to evaluate makes different assumptions at the hospitalization and time horizon levels. At the hospitalization level, the number needed to evaluate assumes that each patient would be evaluated only the first time the ESM score is 6 or higher. For each time horizon, the number needed to evaluate assumes that each patient would be evaluated every time the ESM score is 6 or higher.

Wong, et al. 2021

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Expected AUROC performance ~ 0.8

Wong, et al. 2021

Contingency Table

	Sepsis	No Sepsis	
Alert	843	5,948	**6,791**
No Alert	1,709	29,955	**31,664**
	2,552	**35,903**	**38,445**

When the alert goes off, how often is it correct?

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$$PPV = \frac{TP}{TP + FP} = \frac{843}{6791} \approx 12\,\%$$

How many alerts do I need to evaluate to find a patient with sepsis?

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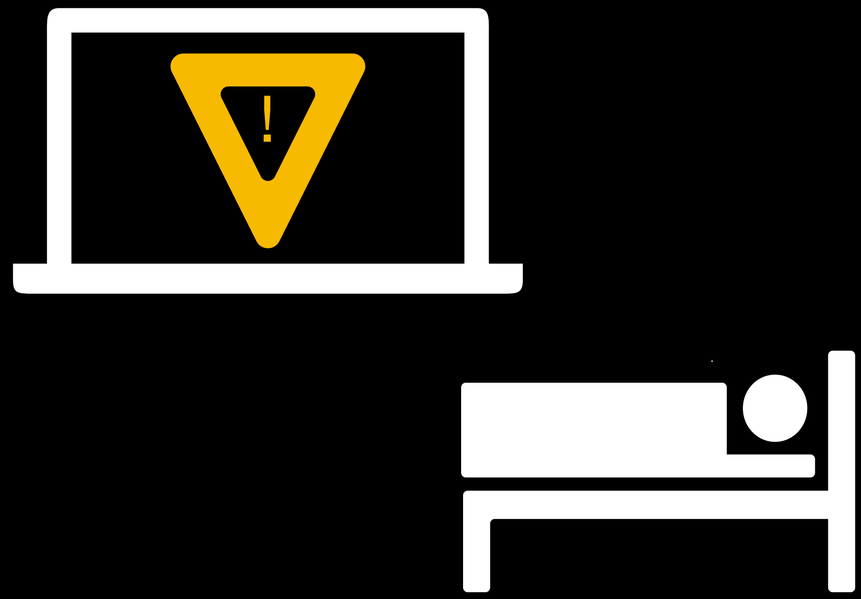
$$NNE = \frac{1}{PPV} = \frac{6791}{843} > 8$$

What about “useful” alerts?

F4/4 (at Michigan)
MVC, +FAST, s/p ex-lap splenectomy 3 days ago

2000
A little more confused, SBPs 100s
You start fluid resuscitation and abx
Pressures respond

Page @0300
Epic Sepsis AI Model sends an alert



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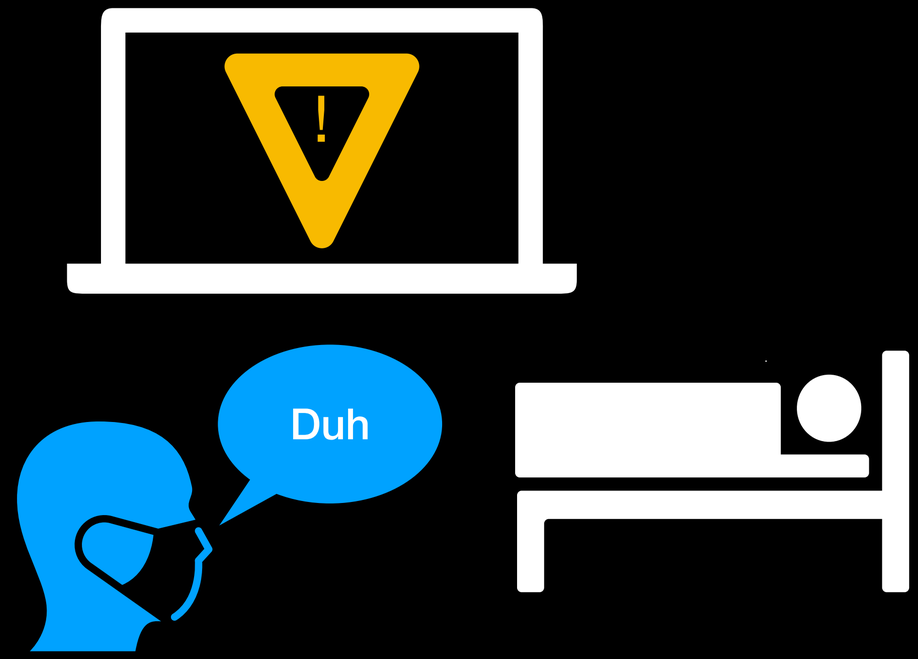

Proxy for useful: already prescribe abx?

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Sepsis Abx
not useful

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Sepsis
Abx
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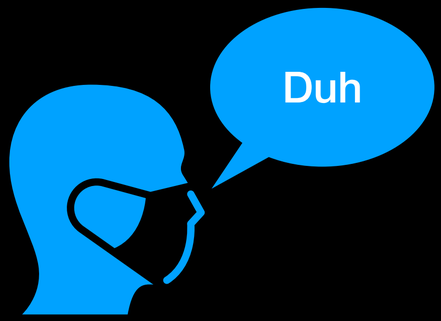

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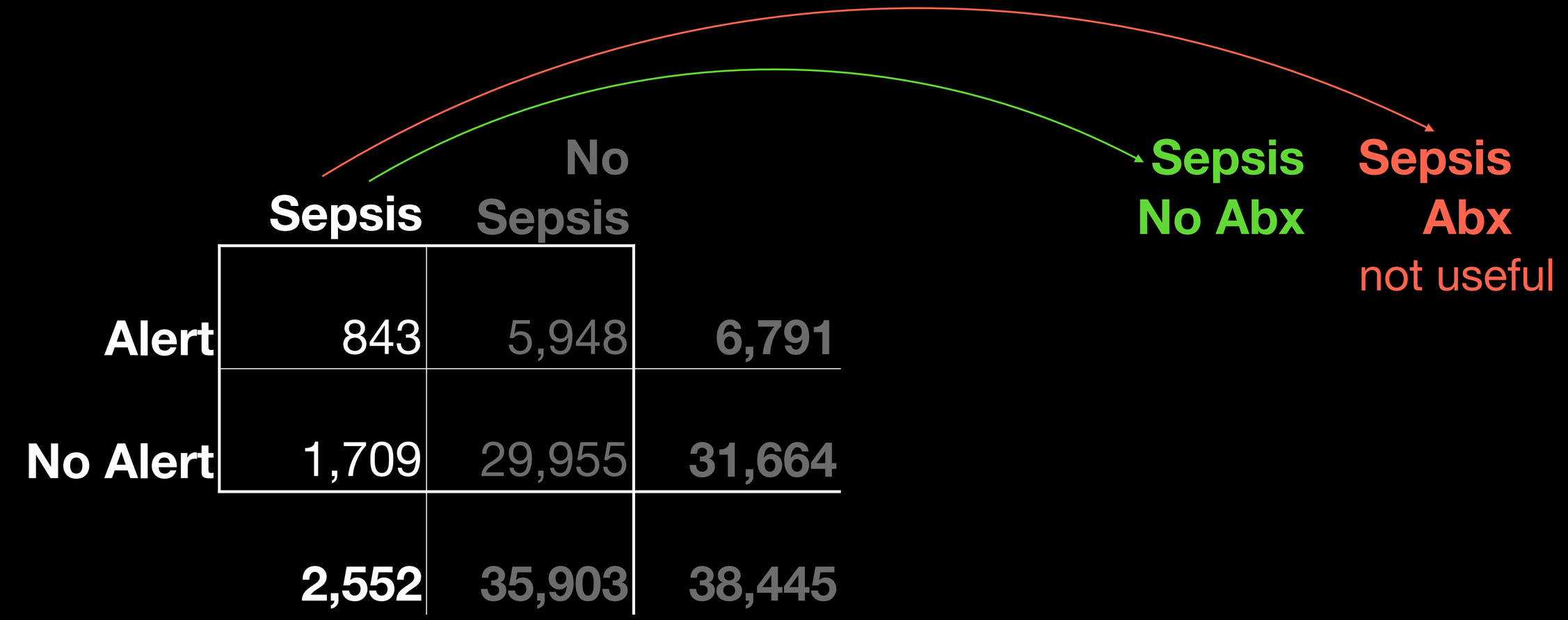

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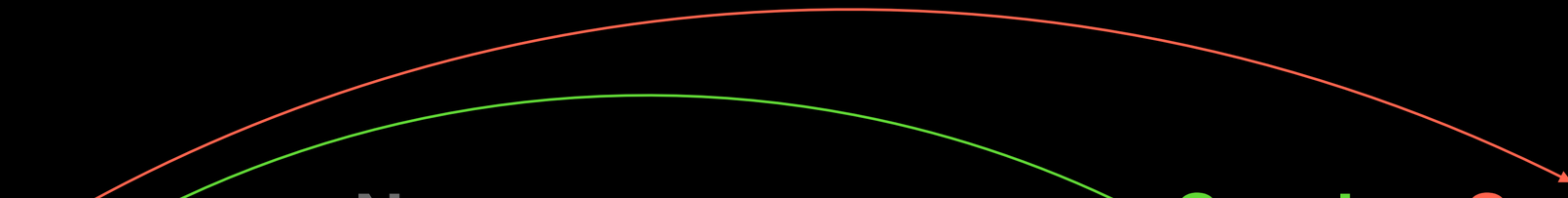
Sepsis Abx not useful

Proxy for useful: already prescribe abx?



	Sepsis	No Sepsis	
Alert	843	5,948	**6,791**
No Alert	1,709	29,955	**31,664**
	2,552	**35,903**	**38,445**

	Sepsis No Abx	Sepsis Abx	
Alert	183	660	**843**
No Alert	679	1,030	**1,709**
	862	**1,690**	**2,552**

How often was the alert useful given it was correct?

	Sepsis No Abx	Sepsis Abx	
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$$P(Useful \mid Correct) = \frac{P(Useful \cap Correct)}{P(Correct)} = \frac{183}{843} \approx 22\,\%$$

So, would you want to use this model?

Why such a big difference between expected & observed performance?

Subtle choice of outcome definition

Development: ICD-9 code indicating diagnosis of sepsis

Evaluation: operational sepsis outcome

Subtle choice of outcome definition

Development: ICD-9 code indicating diagnosis of sepsis

Evaluation: operational sepsis outcome

Billing lags behind actual clinical care

Sensitivity Analysis

When ESM scores up to 3 hours after the onset of sepsis were included, the hospitalization-level AUC improved to 0.80 (95% CI, 0.79-0.81).

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Sensitivity Analysis
When ESM scores up to 3 hours after the onset of sepsis were included, the hospitalization-level AUC improved to 0.80 (95% CI, 0.79-0.81).

makes a big difference

There’s always more evaluation to be done…

CLINICAL INVESTIGATION

Improving Timeliness of Antibiotic Administration Using a Provider and Pharmacist Facing Sepsis Early Warning System in the Emergency Department Setting: A Randomized Controlled Quality Improvement Initiative

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David Bar-Shain, MD[2,3]
Brian M. McCrate, PharmD, BCPS, BCCCP[5]
Lewis H. Reese, PharmD, BCPS[5]
Charles Emerman, MD[3,4]
Jonathan Siff, MD, MBA[2–4]
Christine Wang, BS[3]
David C. Kaelber, MD, PhD, MPH[3,6,7]
Brook Watts, MD, MS[3,8]
Michelle T. Hecker, MD[3,9]

OBJECTIVES: Results of pre-post intervention studies of sepsis early warning systems have been mixed, and randomized clinical trials showing efficacy in the emergency department setting are lacking. Additionally, early warning systems can be resource-intensive and may cause unintended consequences such as antibiotic or IV fluid overuse. We assessed the impact of a pharmacist and provider facing sepsis early warning systems on timeliness of antibiotic administration and sepsis-related clinical outcomes in our setting.

DESIGN: A randomized, controlled quality improvement initiative.

SETTING: The main emergency department of an academic, safety-net healthcare system from August to December 2019.

PATIENTS: Adults presenting to the emergency department.

INTERVENTION: Patients were randomized to standard sepsis care or standard care augmented by the display of a sepsis early warning system–triggered flag in the electronic health record combined with electronic health record–based emergency department pharmacist notification.

MEASUREMENTS AND MAIN RESULTS: The primary process measure was time to antibiotic administration from arrival. A total of 598 patients were included in the study over a 5-month period (285 in the intervention group and 313 in the standard care group). Time to antibiotic administration from emergency department arrival was shorter in the augmented care group than that in the standard care group (median, 2.3 hr [interquartile range, 1.4–4.7 hr] vs 3.0 hr [interquartile range, 1.6–5.5 hr]; $p = 0.039$). The hierarchical composite clinical outcome measure of days alive and out of hospital at 28 days was greater in the augmented care group than that in the standard care group (median, 24.1 vs 22.5 d; $p = 0.011$). Rates of fluid resuscitation and antibiotic utilization did not differ.

CONCLUSIONS: In this single-center randomized quality improvement initiative, the display of an electronic health record–based sepsis early warning system–triggered flag combined with electronic health record–based pharmacist notification was associated with shorter time to antibiotic administration without an increase in undesirable or potentially harmful clinical interventions.

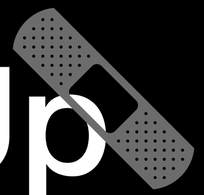
KEY WORDS: decision support; early warning system; electronic health record; emergency department; sepsis

Sepsis is a prevalent, costly, and life-threatening condition (1). Data from observational studies suggest that earlier identification and treatment of sepsis may be associated with better clinical outcomes (2–5).

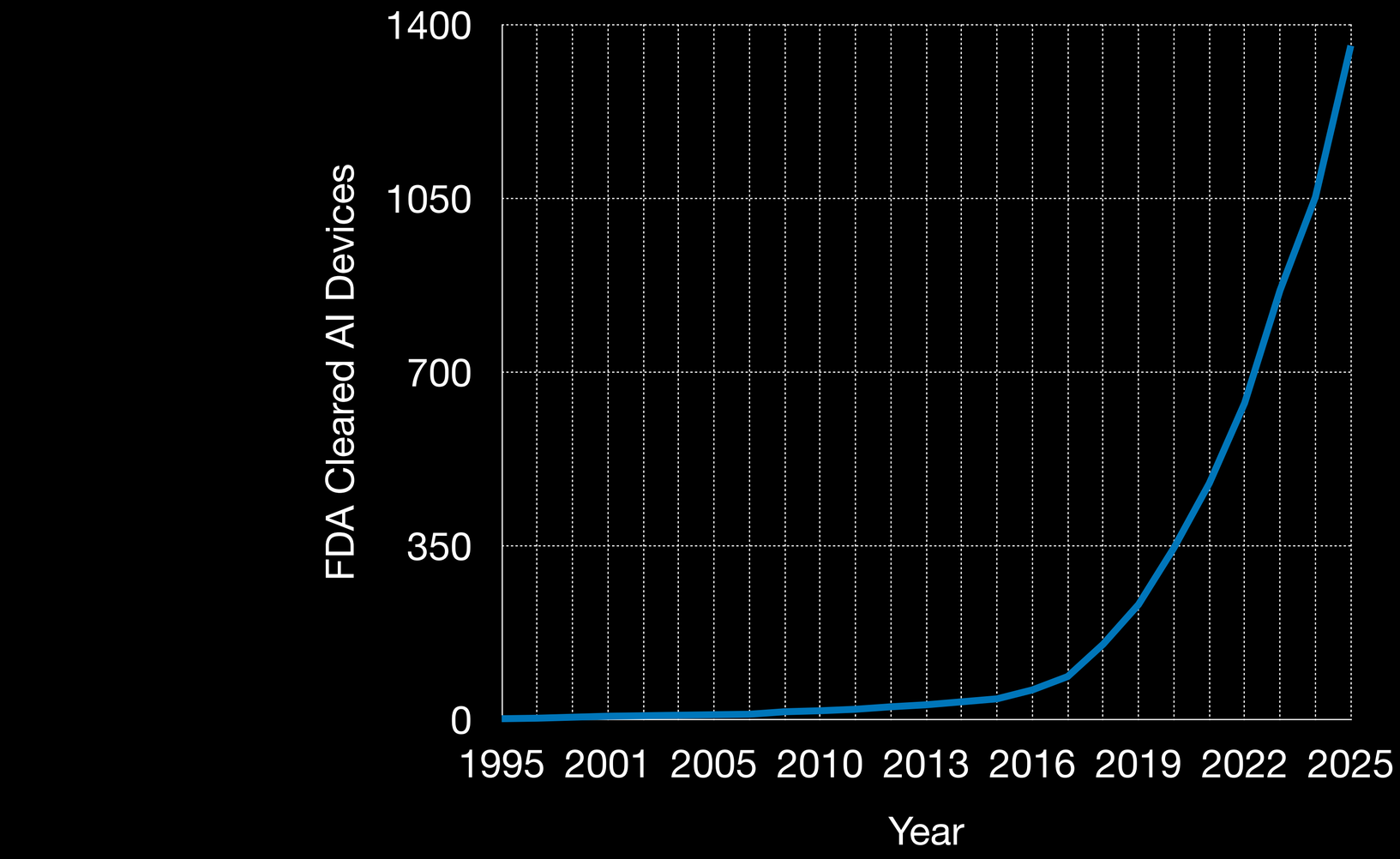
DOI: 10.1097/CCM.0000000000005267

Tarabichi, et al. 2022

Wrapping Up



Wrapping Up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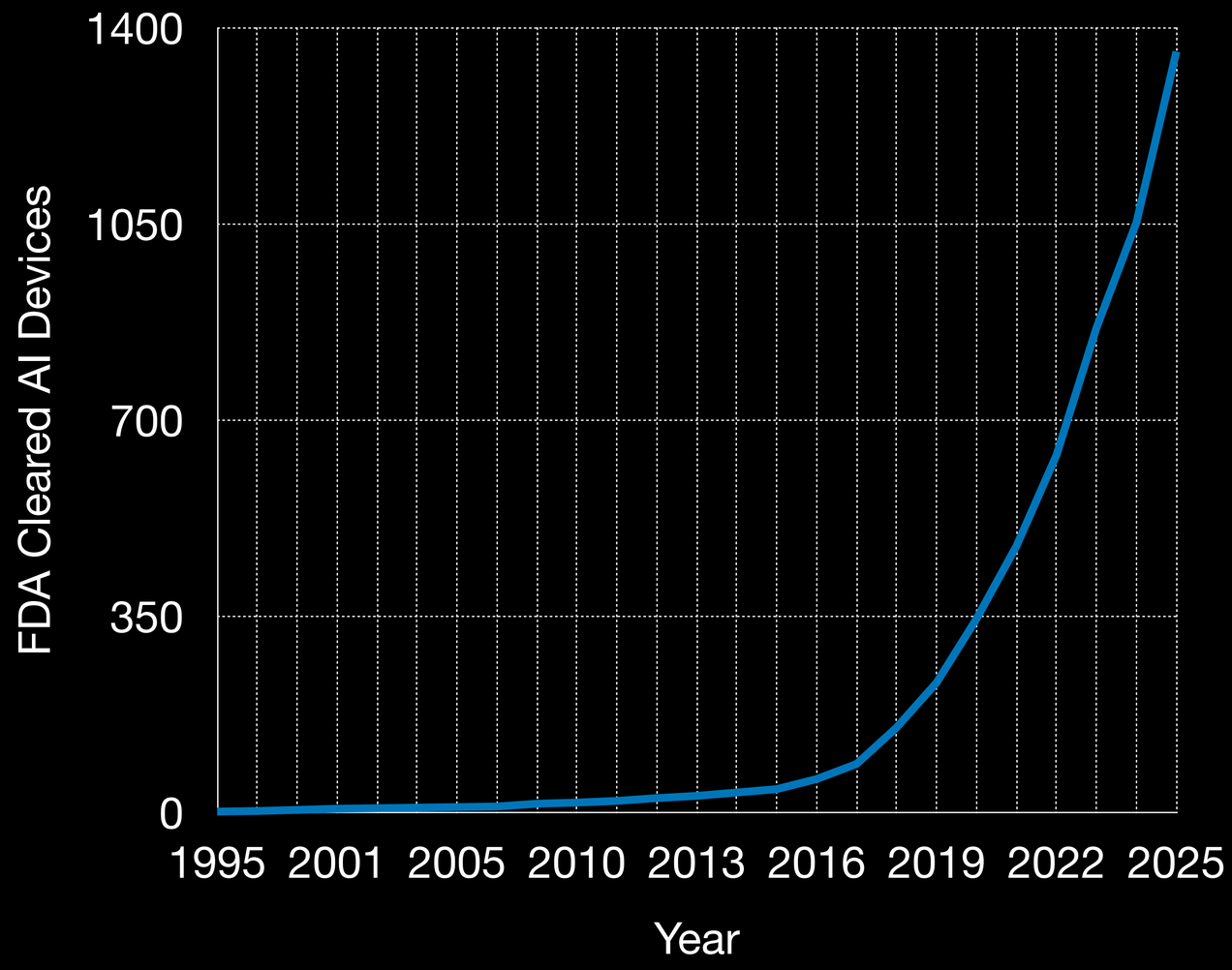
Year

Wrapping Up

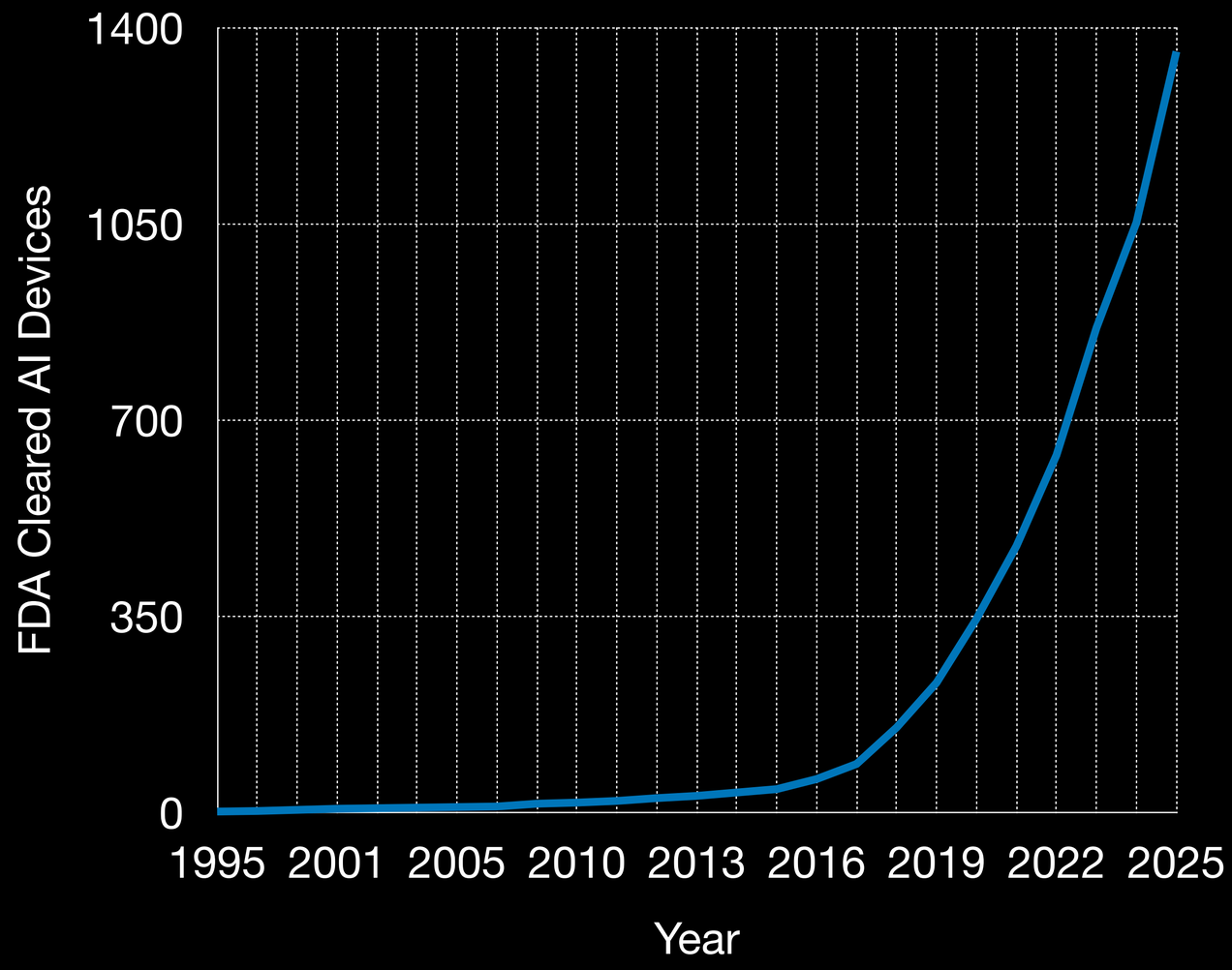
Predictive Models: Inputs → Predictions



Wrapping Up

Predictive Models: Inputs → Predictions

Built on data & assumptions

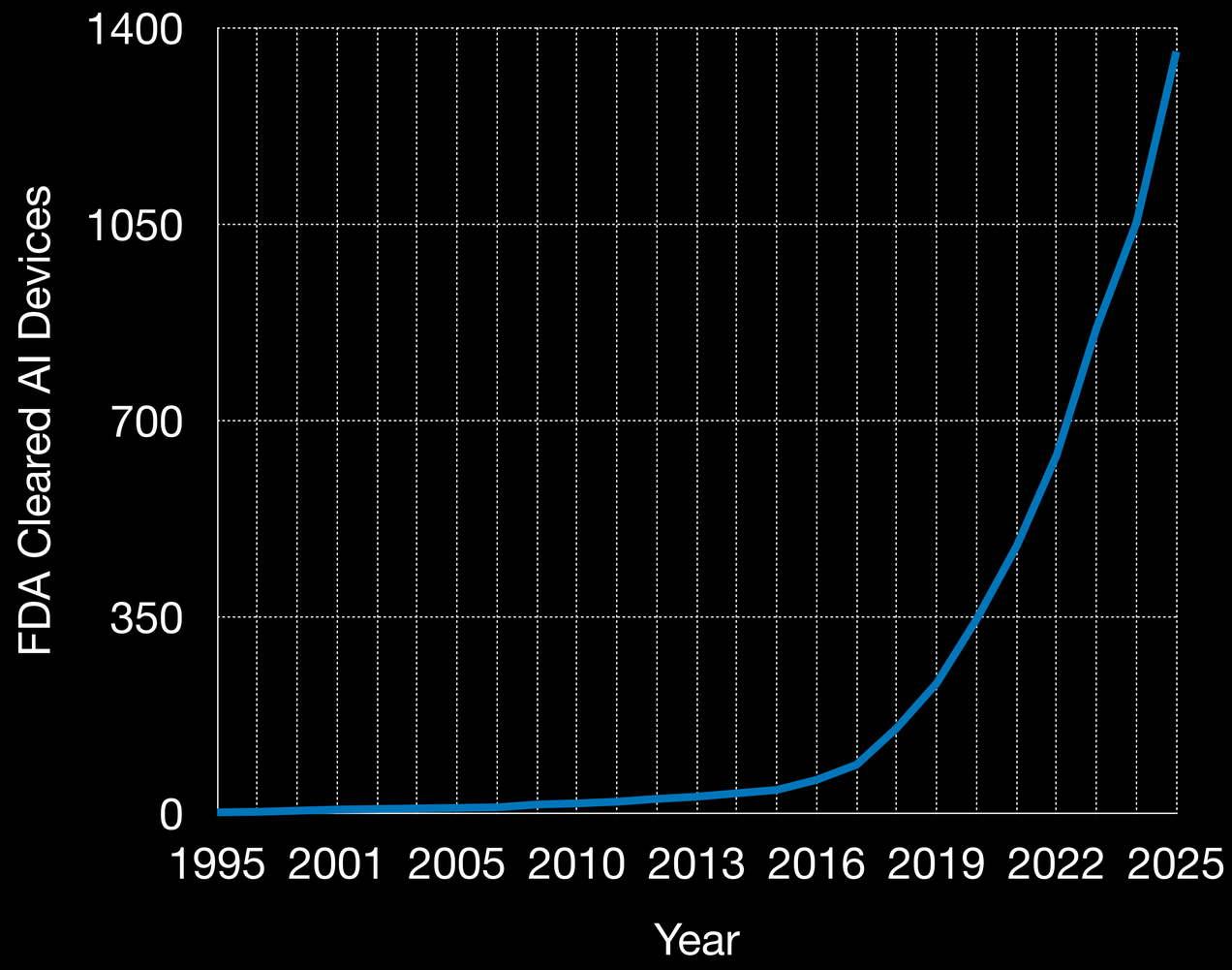


Wrapping Up

Predictive Models: Inputs → Predictions

Built on data & assumptions

Bad vibes → investigate



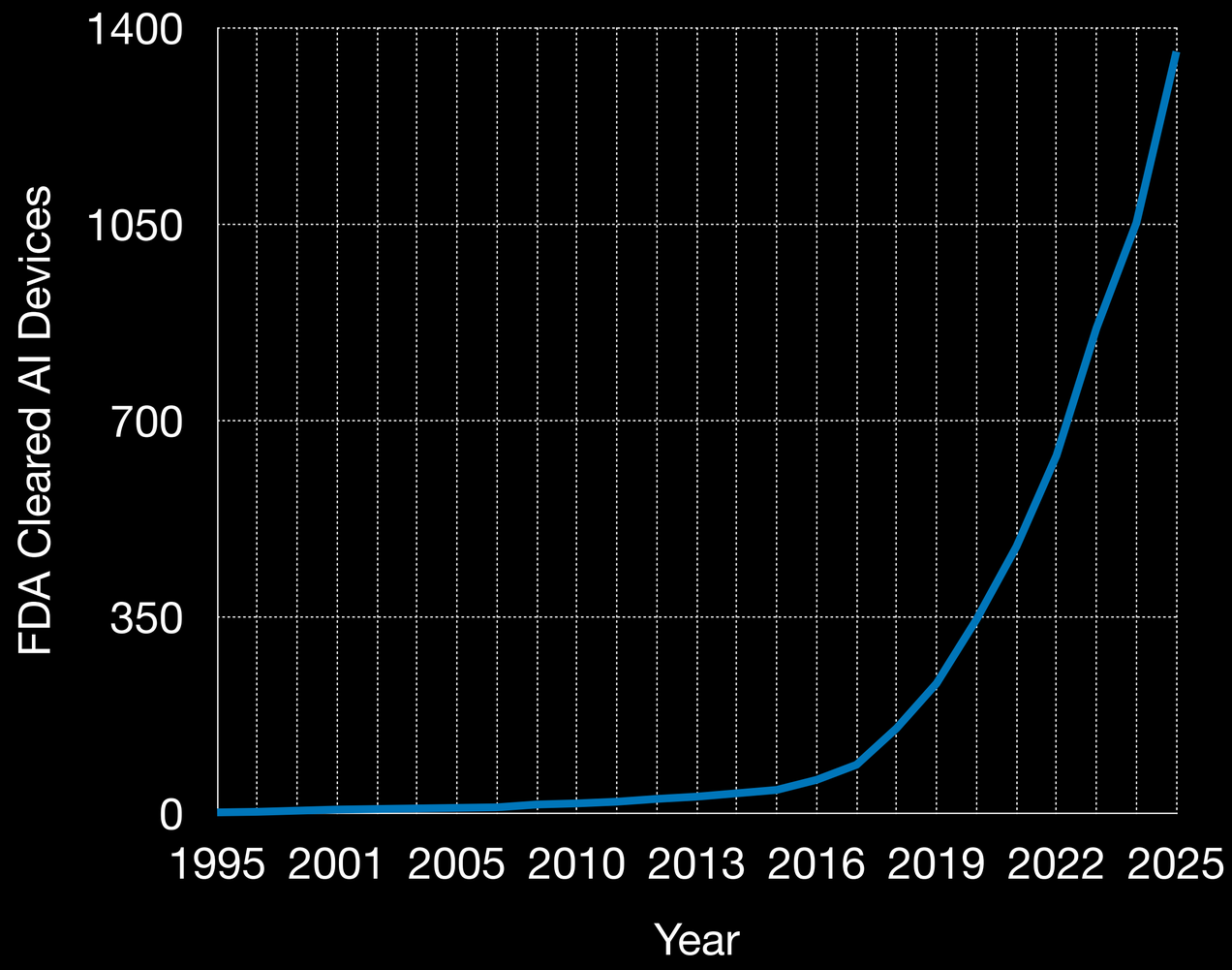
Wrapping Up

Predictive Models: Inputs → Predictions

Built on data & assumptions

Bad vibes → investigate

Evaluation needs clinical judgement



Wrapping Up

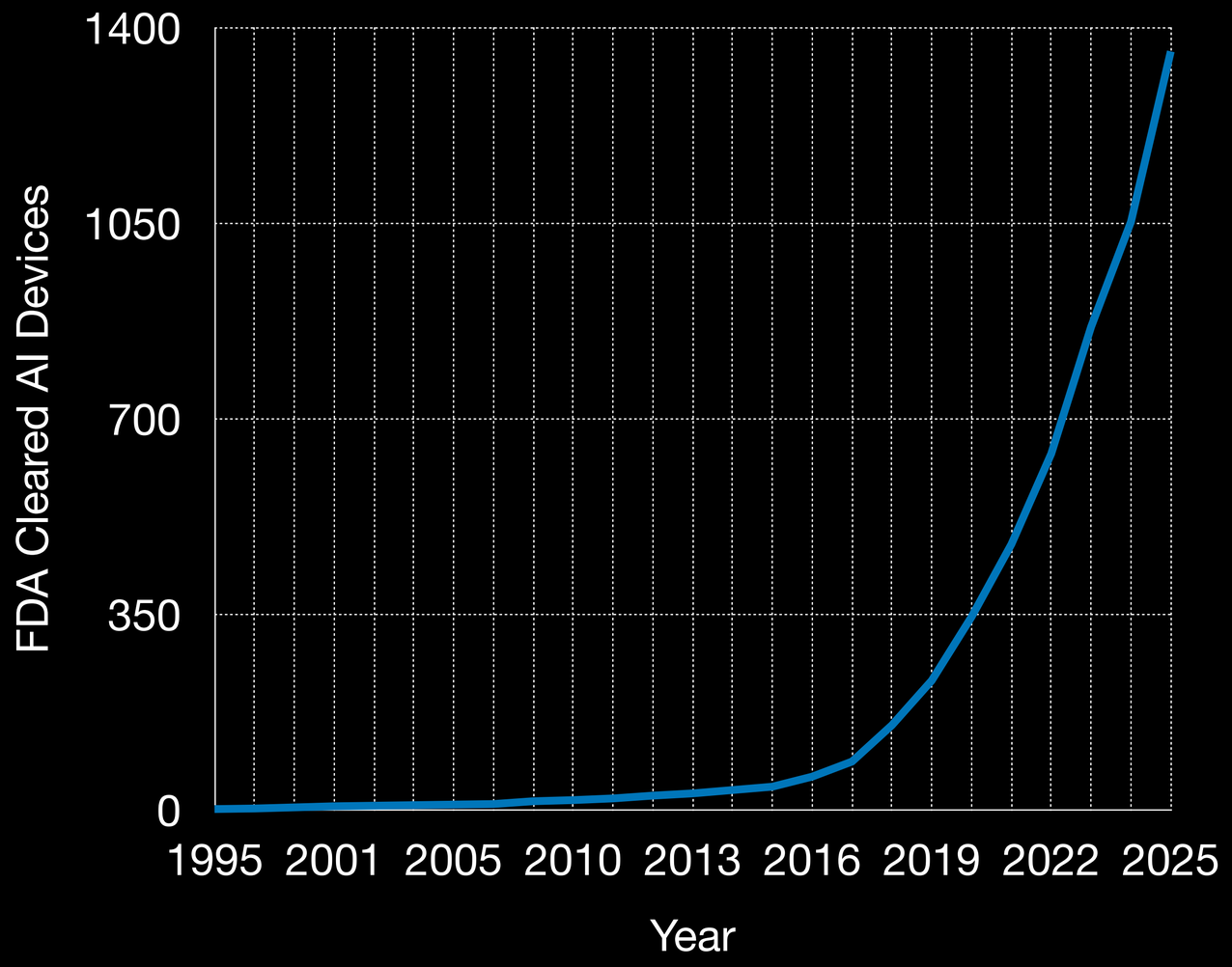
Predictive Models: Inputs → Predictions

Built on data & assumptions

Bad vibes → investigate

Evaluation needs clinical judgement

“All models are wrong, but some are useful”
- George Box



Appendices

EDT Appendix

EDT References

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EDT Additional Resources

LITFL Resuscitative Thoracotomy
https://litfl.com/resuscitative-thoracotomy/

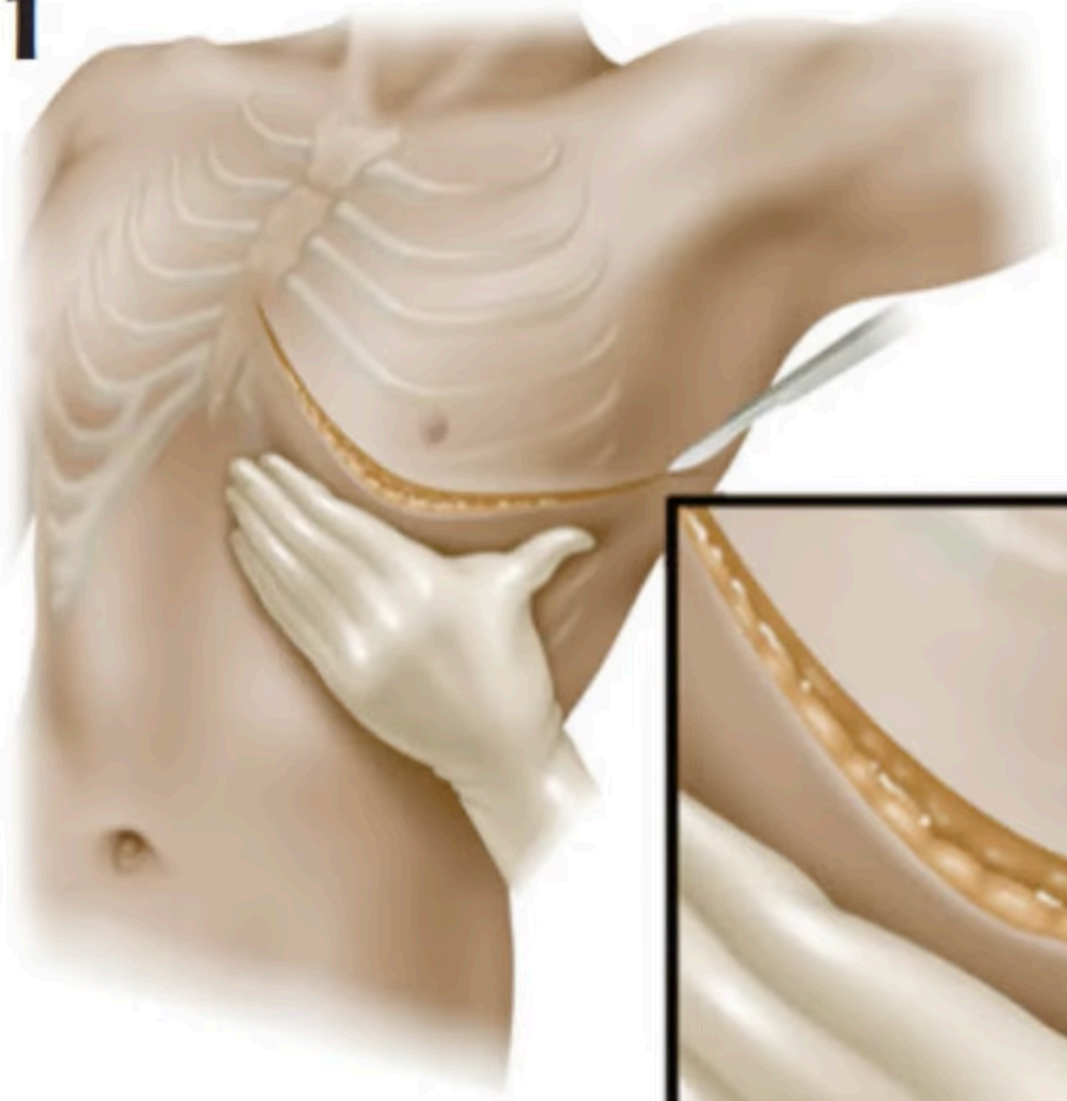
EMCrit-Abbreviated-Thoracotomy-Tray
https://www.youtube.com/watch?v=924t8kpW-p4

Hinds: Crack the Chest. Get Crucified
https://www.youtube.com/watch?v=GFX_tocJShA

Getting to the Heart of the Matter: Breaking Down the Resuscitative Thoracotomy
https://www.youtube.com/watch?v=crWwSpv3Z8Q

EDT: Left Anterolateral Thoracotomy

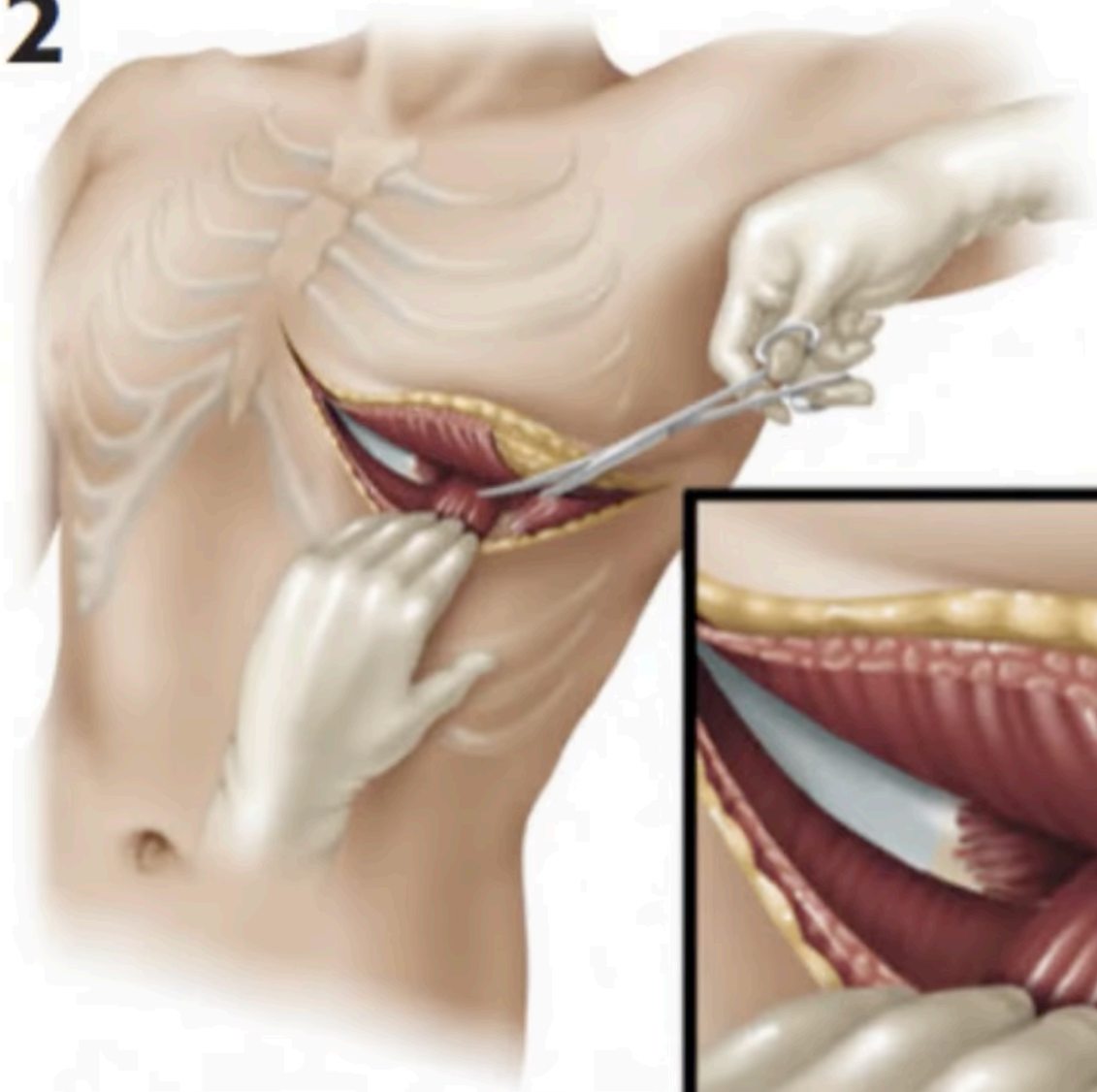
1



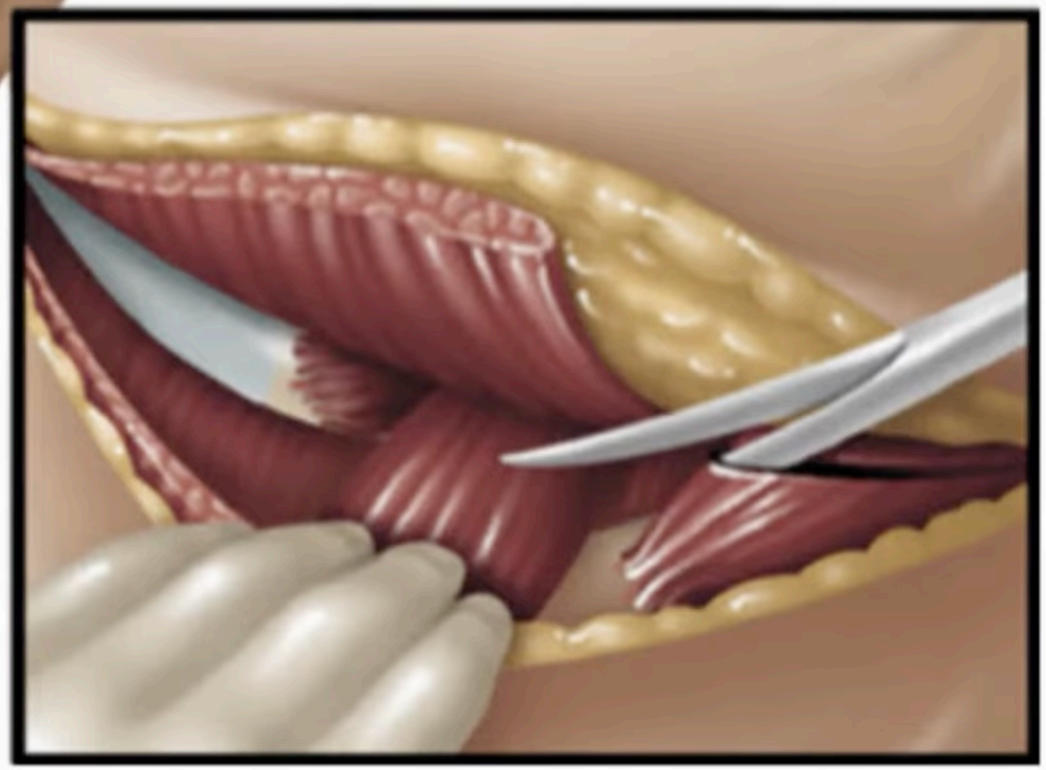
Make an anterolateral incision at the 4th to 5th intercostal space.

Begin at the right side of the sternum and extend the incision past the posterior axillary line.

2



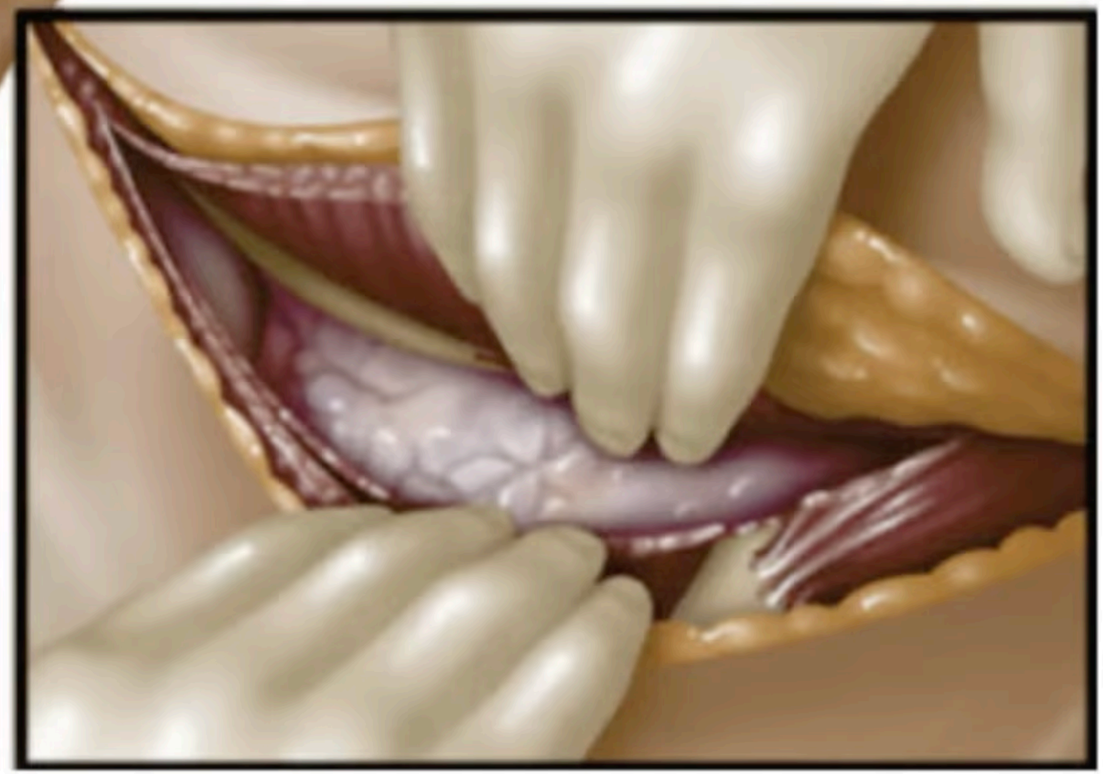
Cut the intercostal muscles with scissors.



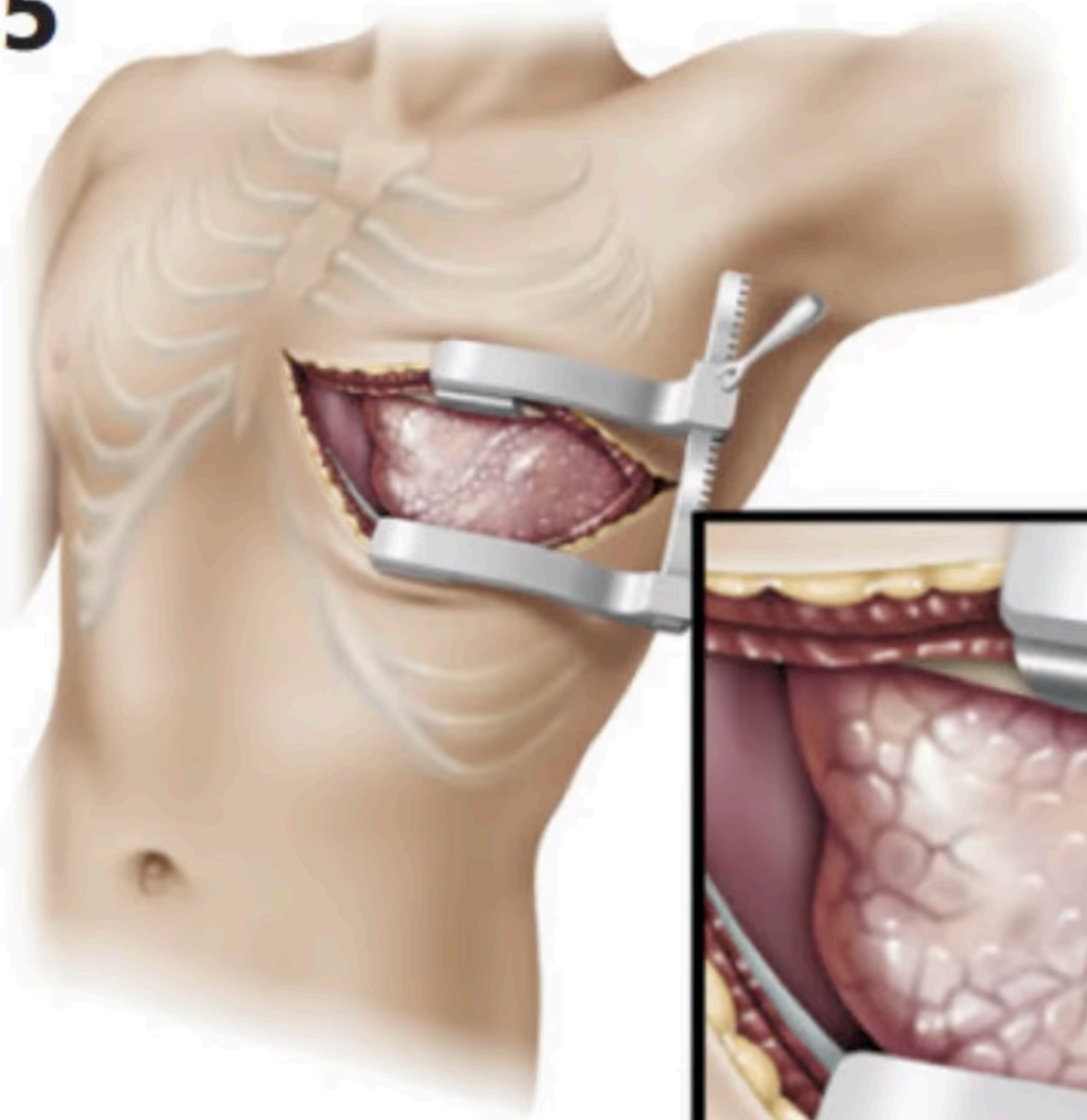
Incise along the top of the rib to avoid the intercostal artery.

4

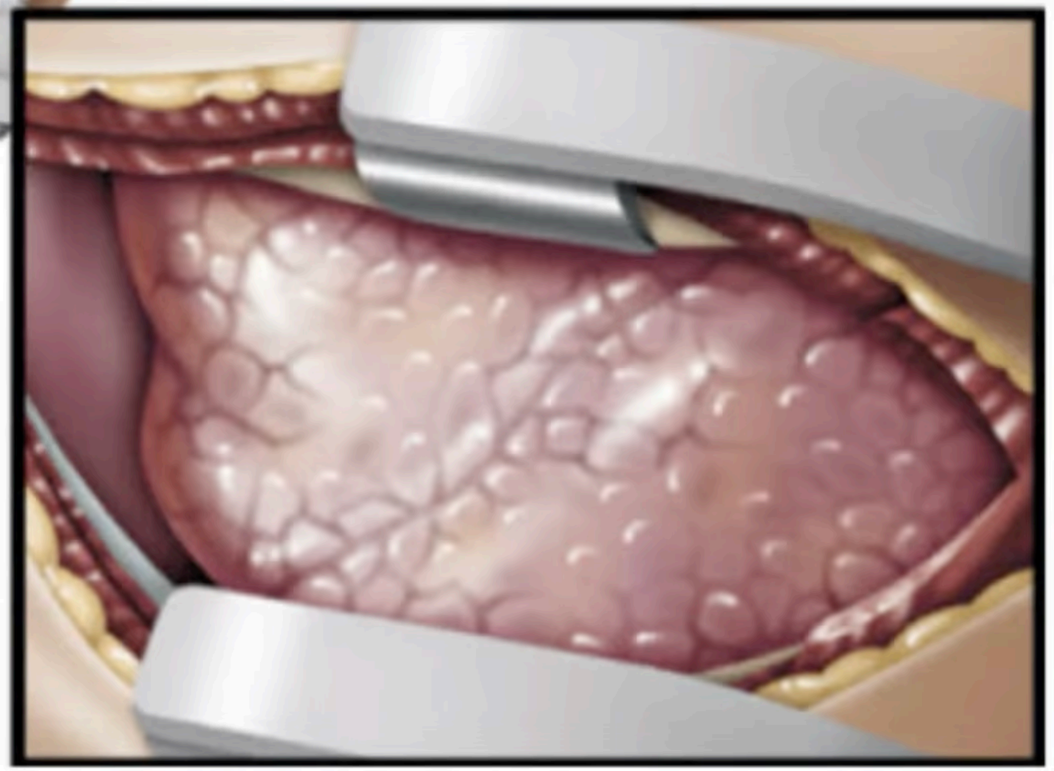
Use your hands to spread the ribs.



5

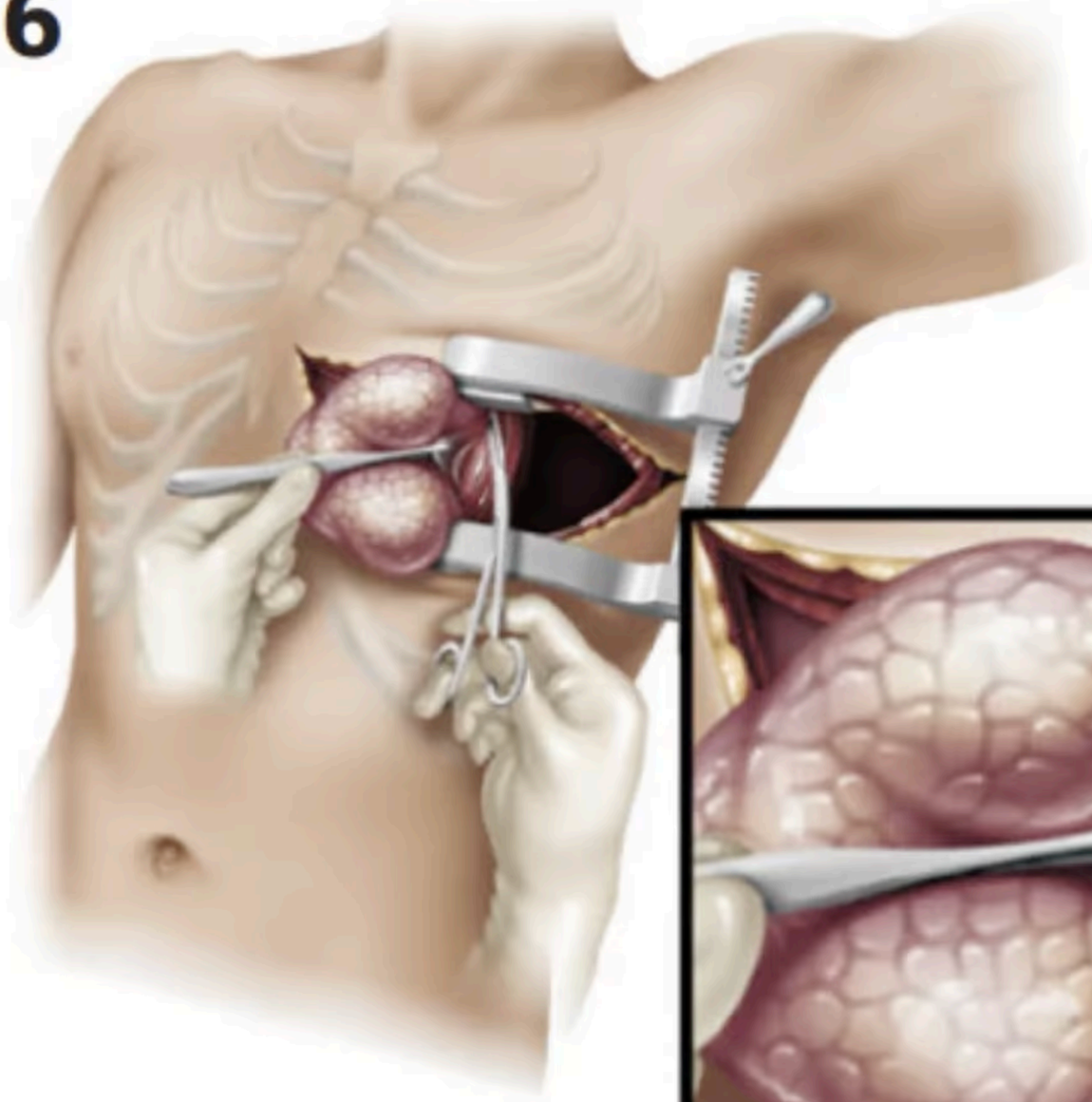


Place a rib spreader between the ribs with the handle and ratchet bar facing downward.



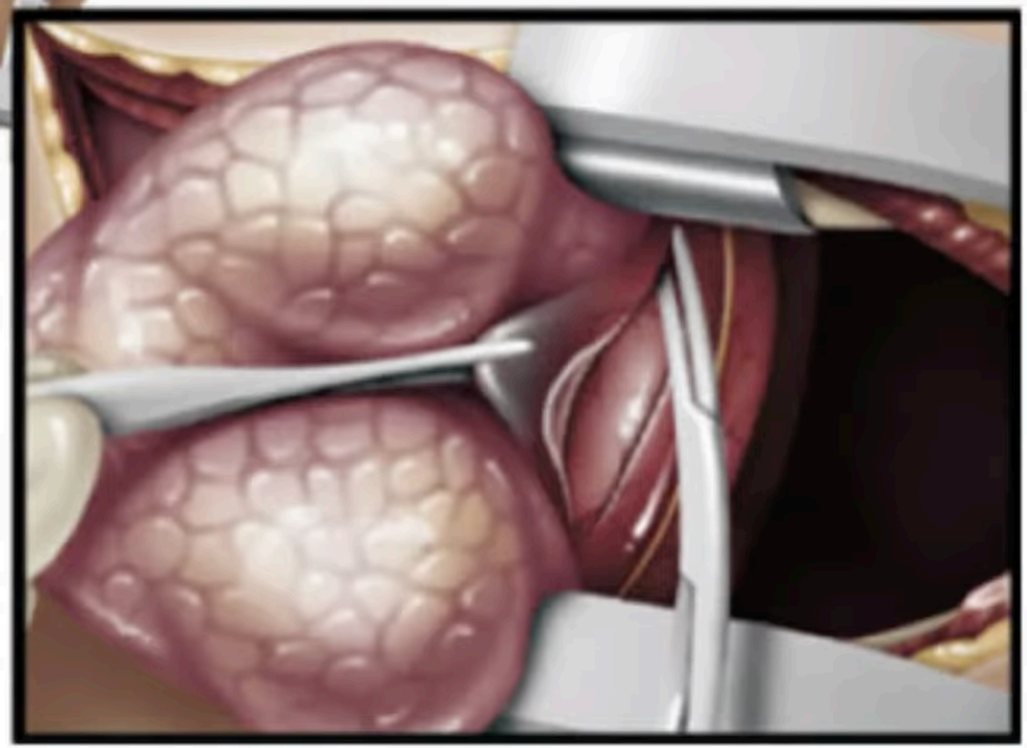
Carefully spread the ribs open.

6



PERICARDIOTOMY

Lift the pericardial sac with forceps, and cut pericardium with scissors.

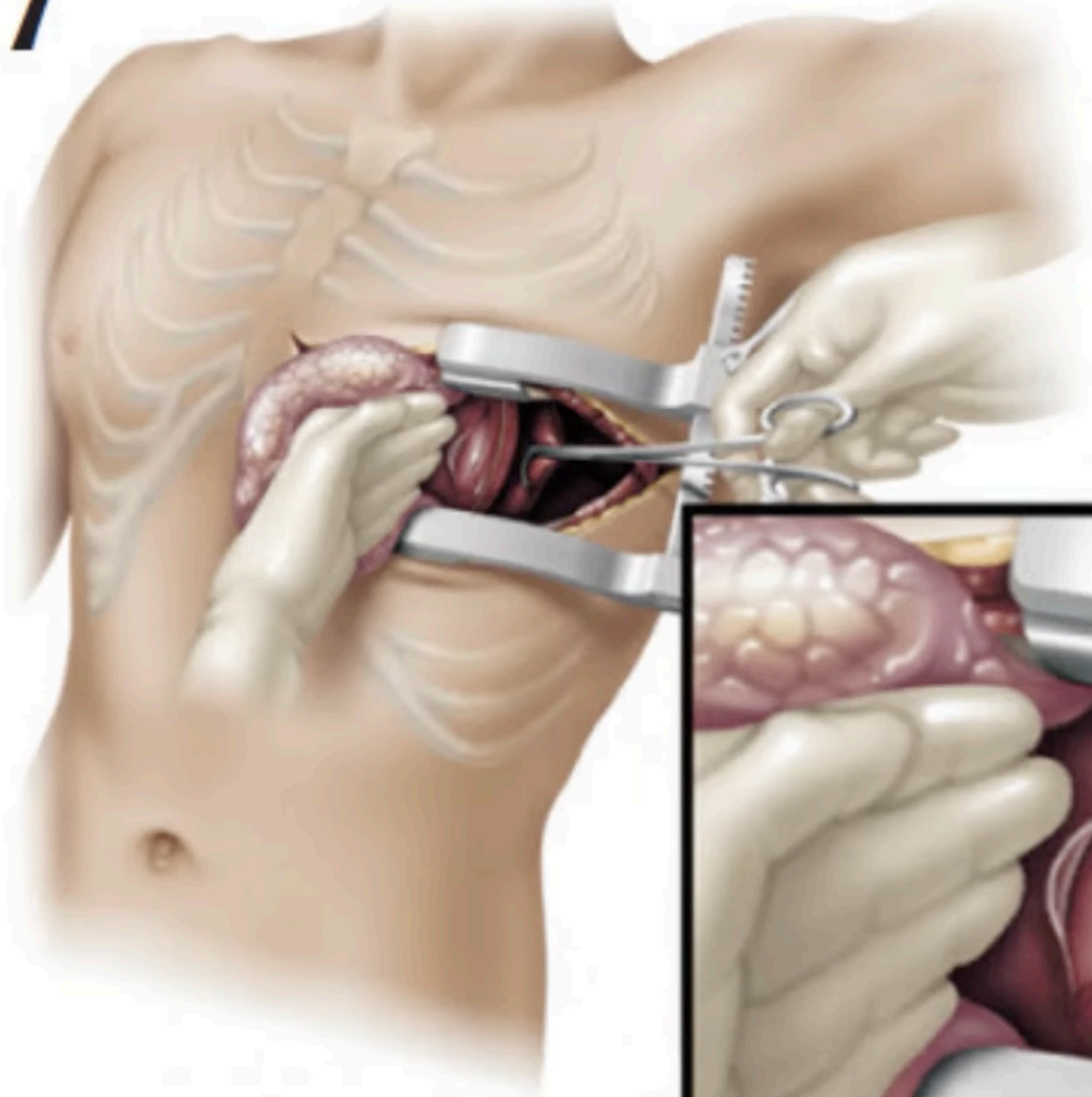


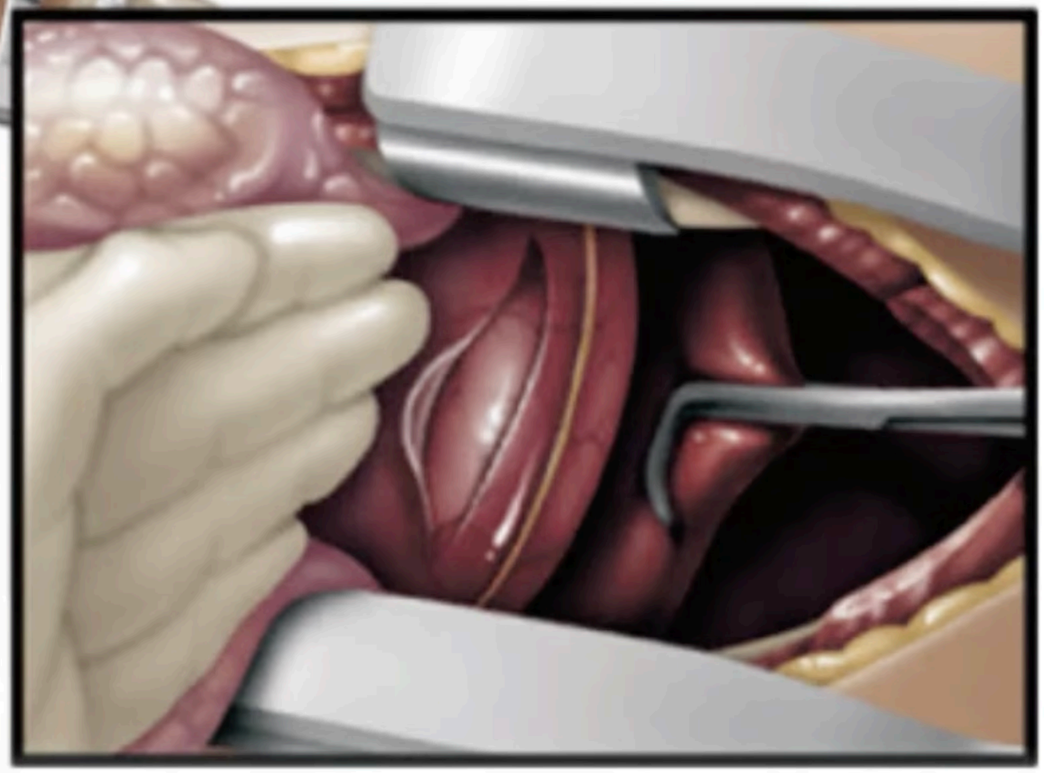
Incise in a caudal-to-cephalad direction; stay anterior and parallel to the phrenic nerve.

7

AORTIC CROSS-CLAMPING

Bluntly dissect the surrounding fascia and temporarily apply an aortic clamp.

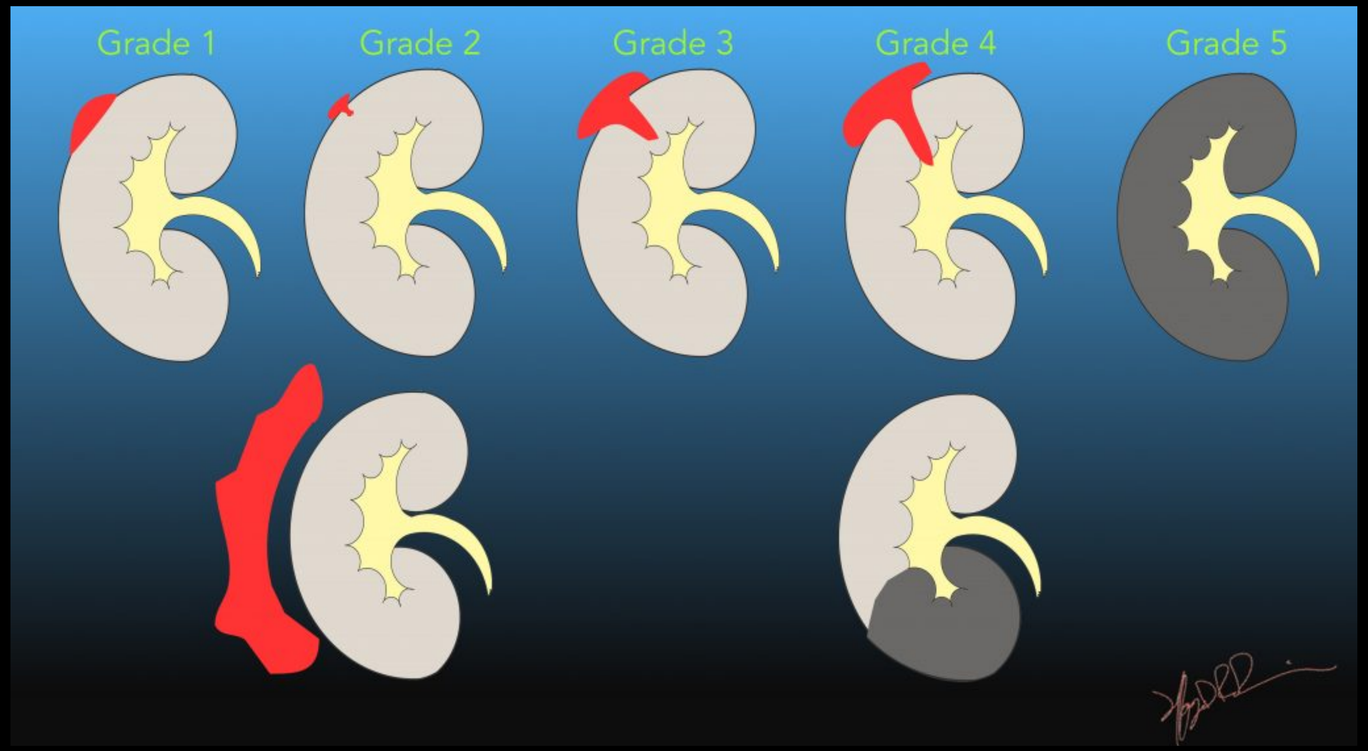




Place OG to help demarcate the esophagus

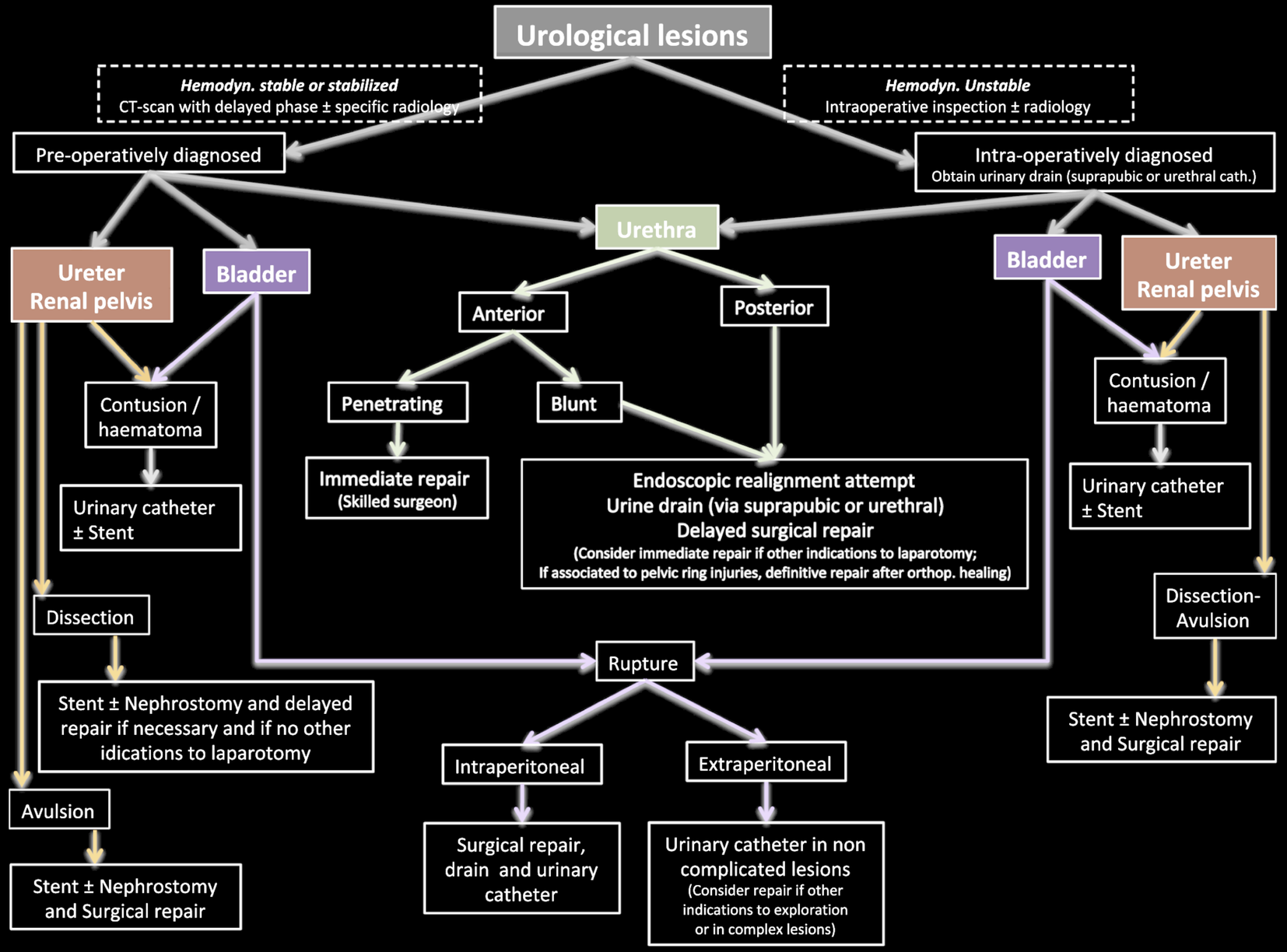
Traumatic Hematuria Appendix

AAST Kidney Injury Scale



American Association for Surgery of Trauma Renal Injury Scale		
Grade	**Type**	**Description**
I	Contusion	Microscopic or gross haematuria. Urological studies normal.
	Haematoma	Subcapsular, non-expanding without parenchymal laceration.
II	Haematoma	Non-expanding peri-renal haematoma confined to renal retroperitoneum.
	Laceration	< 1.0cm parenchymal depth of renal cortex with no urinary extravasation.
III	Laceration	> 1.0cm parenchymal depth of renal cortex w/out collecting system rupture or urinary extravasation.
IV	Laceration	Parenchymal laceration extending through renal cortex, medulla & collecting system.
	Vascular	Main renal artery or vein injury with contained haemorrhage.
V	Laceration	Completely shattered kidney.
	Vascular	Avulsion of renal hilum that devascularises kidney.

UW Radiology | AAST Kidney Injury Scale; Coccolini, et al. 2019



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Traumatic Hematuria References

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Evaluation of Predictive AI Models Appendix

Evaluation of Predictive AI Models References

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Contingency Table

	Sepsis	No Sepsis	
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No Alert	1,709	29,955	**31,664**
	2,552	**35,903**	**38,445**

$$Sens = \frac{TP}{TP + FN} = \frac{843}{2552} \approx 33\,\%$$

$$Spec = \frac{TN}{TN + FP} = \frac{29955}{35903} \approx 83\,\%$$

$$PPV = \frac{TP}{TP + FP} = \frac{843}{6791} \approx 12\,\%$$

$$NPV = \frac{TN}{TN + FN} = \frac{29955}{31664} \approx 95\,\%$$

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