Scintigraphy (Nuclear Medicine Imaging) in Patients with Perplexing Abdominal Complaints

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Learning Objectives:

Define …

1. Nuclear Medicine and Its Basic Principles

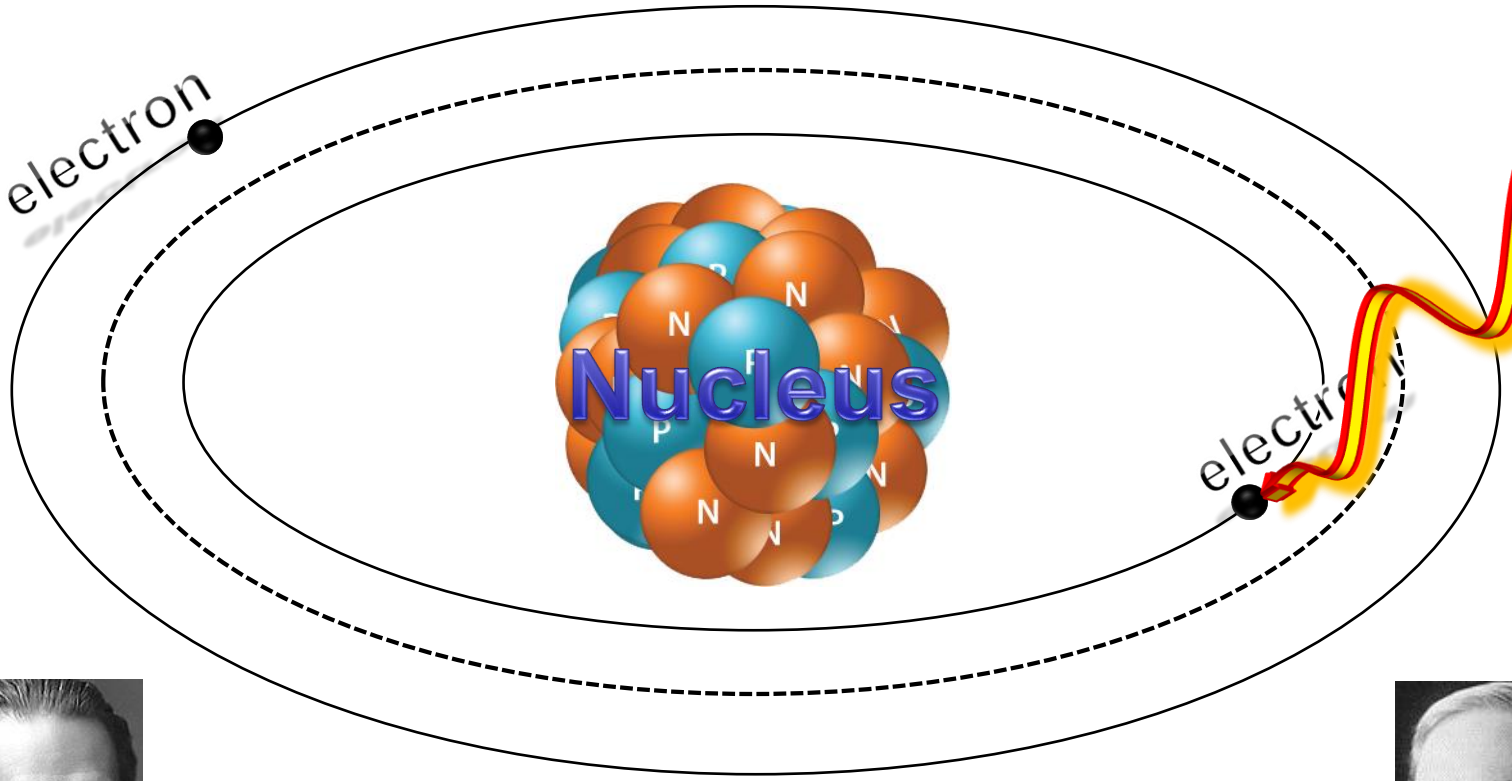
Define Indications for …

2. Hepatobiliary Scintigraphy
   - Functional Gallbladder Disorder
   - Chronic Cholecystitis
   - Related Conditions

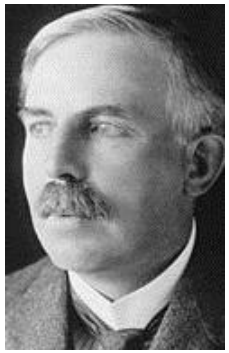
Nuclear Medicine - Definition

A medical specialty that utilizes radioactive isotopes or pharmaceuticals labeled with radioisotopes (called “radiotracers” or ”radiopharmaceuticals”) for diagnostic and therapeutic purposes.

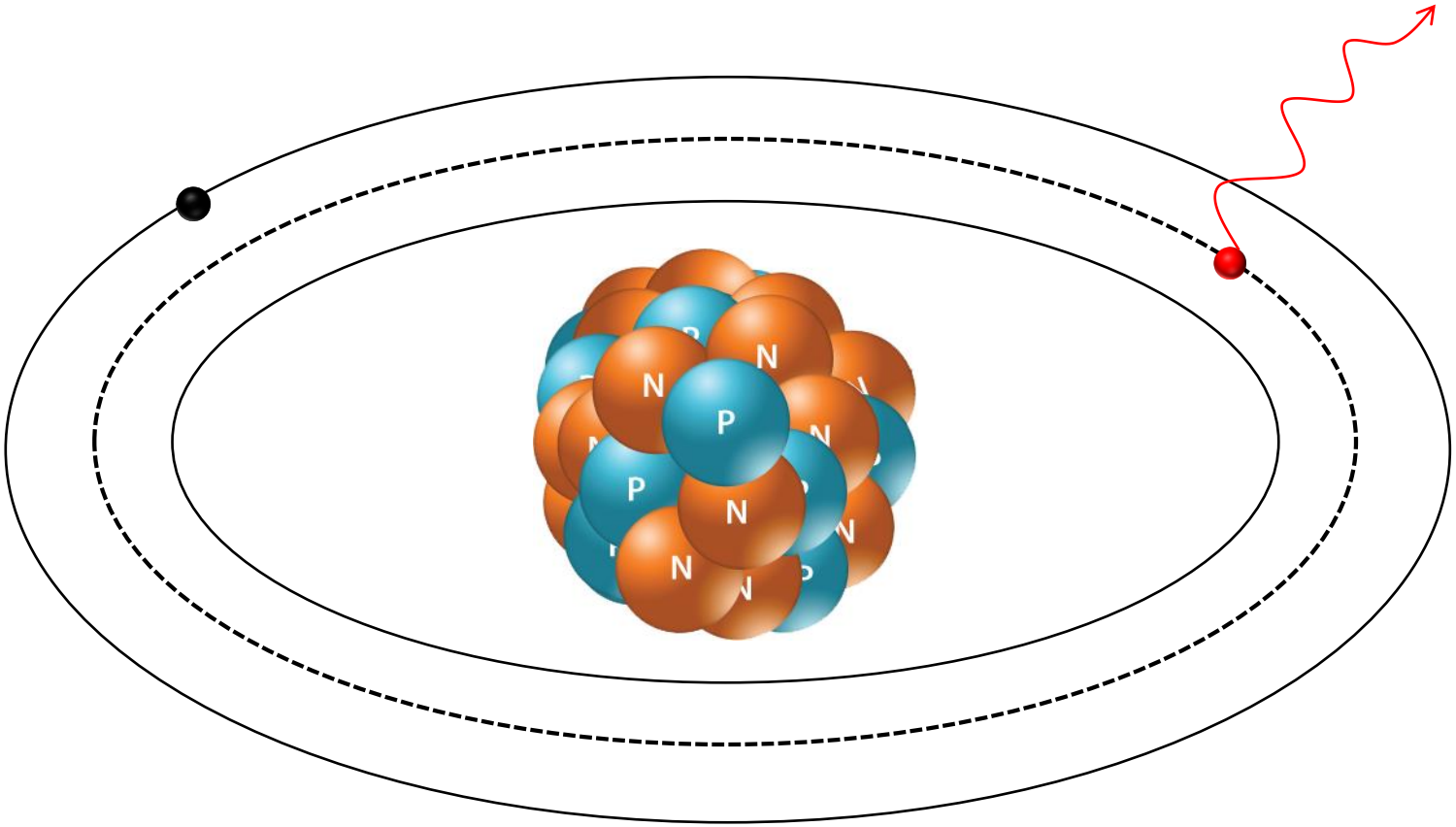
OK, but why “Nuclear” Medicine?
Why not .. say … “Radioisotopic” or … “Radioactive” Medicine?!



Niels Bohr and Ernest Rutherford
Atomic Model, circa 1913



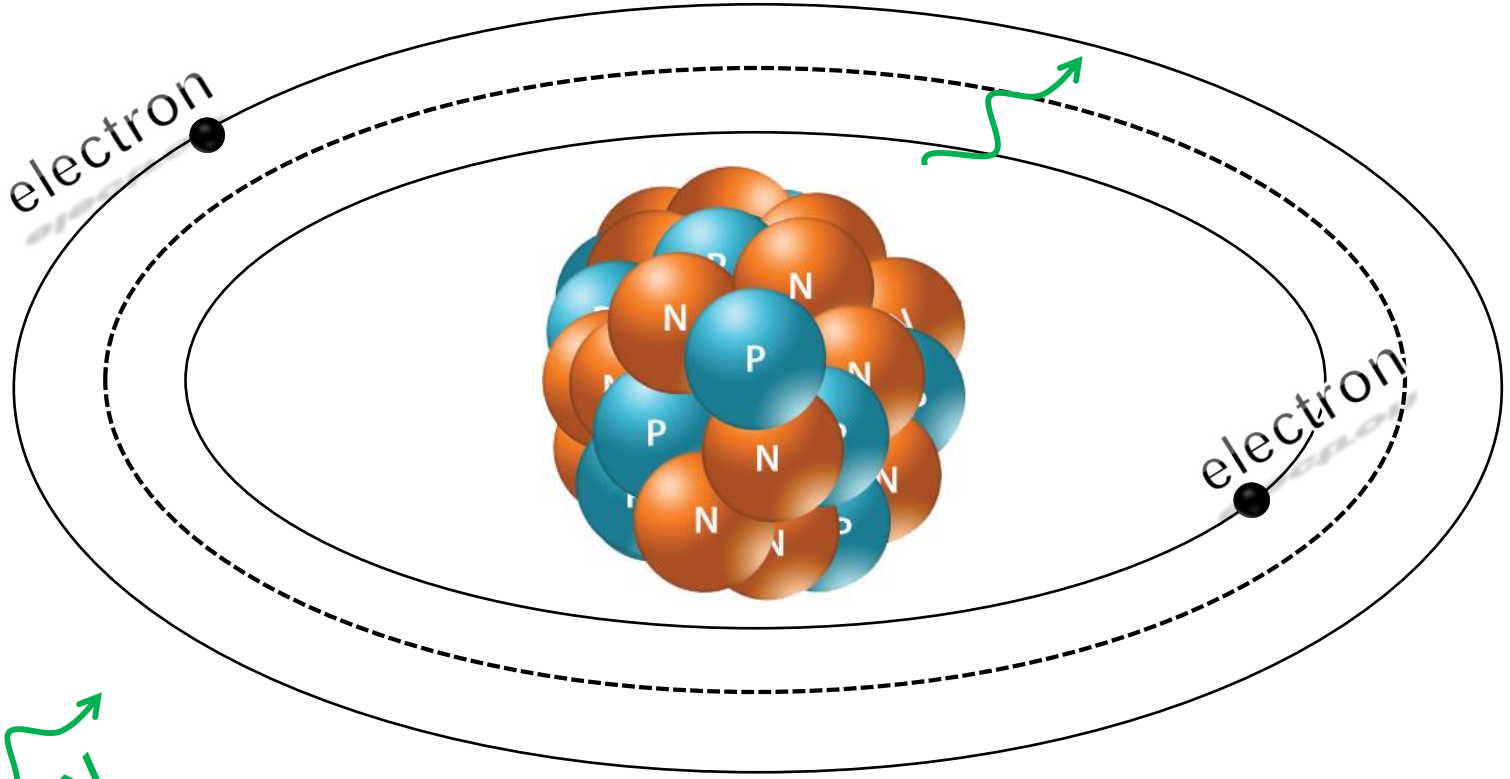
This is how x-Rays are made, always ex-vivo.
They define most examinations in Radiology.



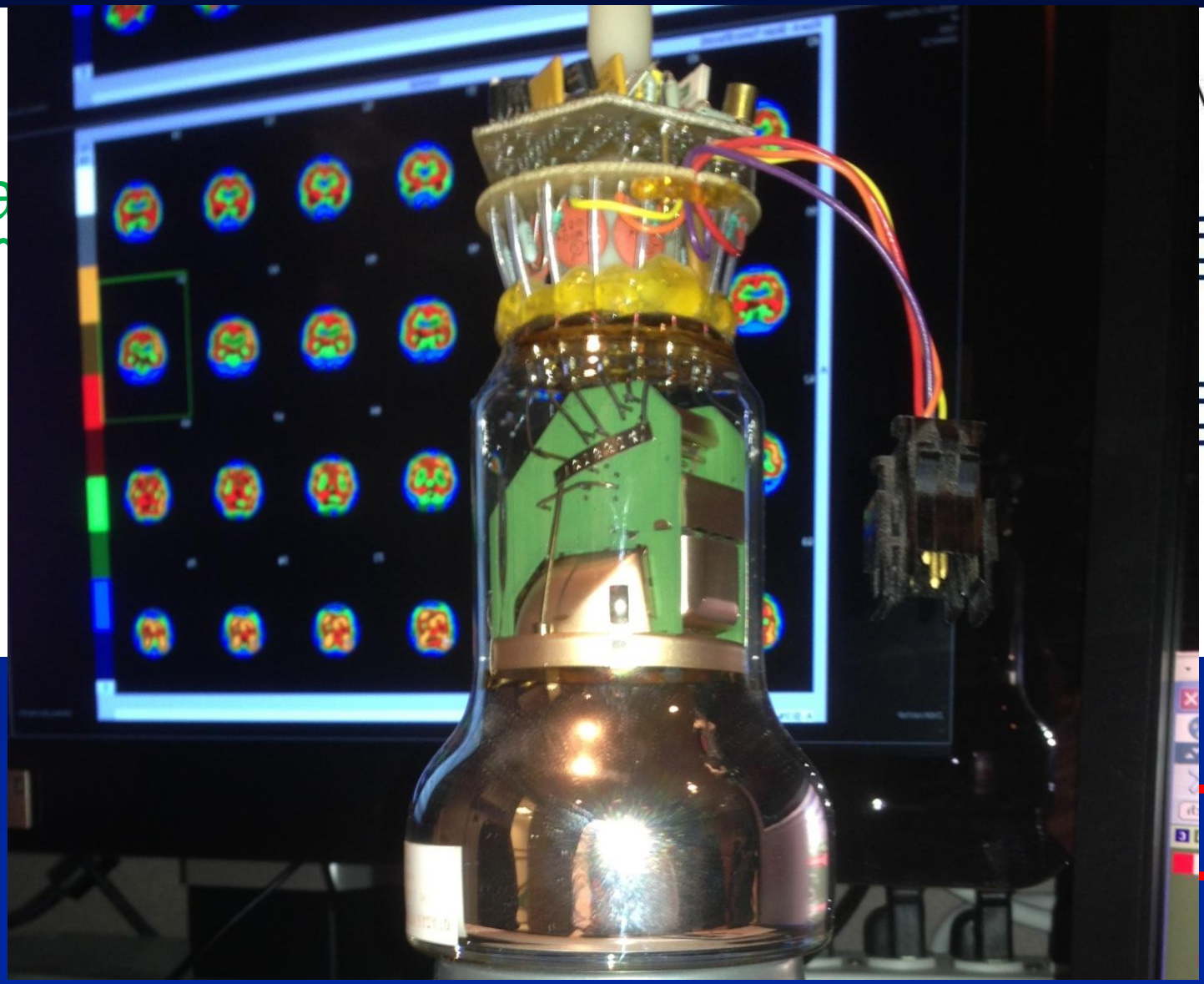
Radioactive Isotopes have Unstable Nucleus

Thus, Nuclear Medicine!

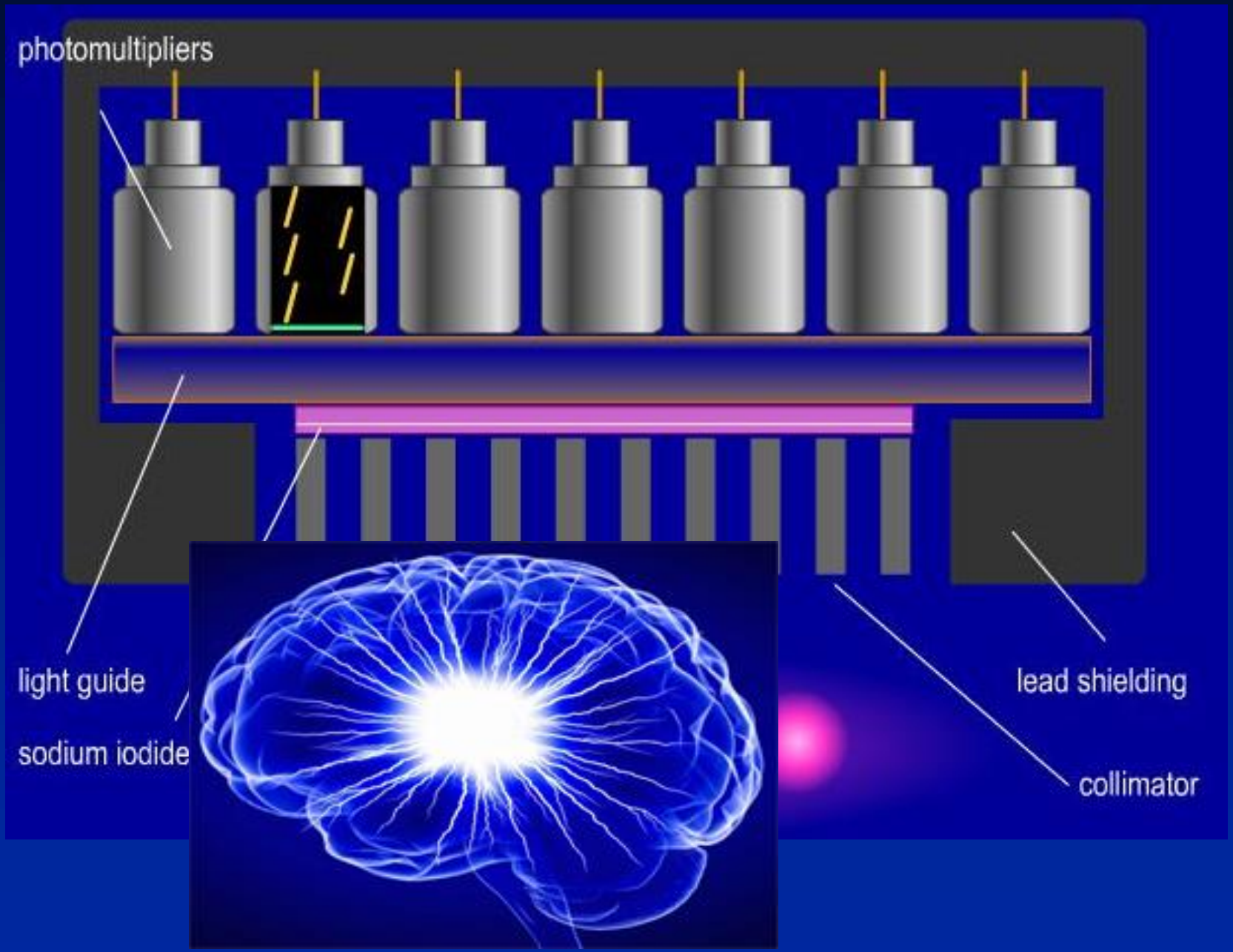
Radiotracers emit excess energy, **γ-Rays**, from within patients.



Scintillator - Photomultiplier Tube (PMT): γ-Photon → Electric Pulse



Gamma Camera = Images Gamma Emission



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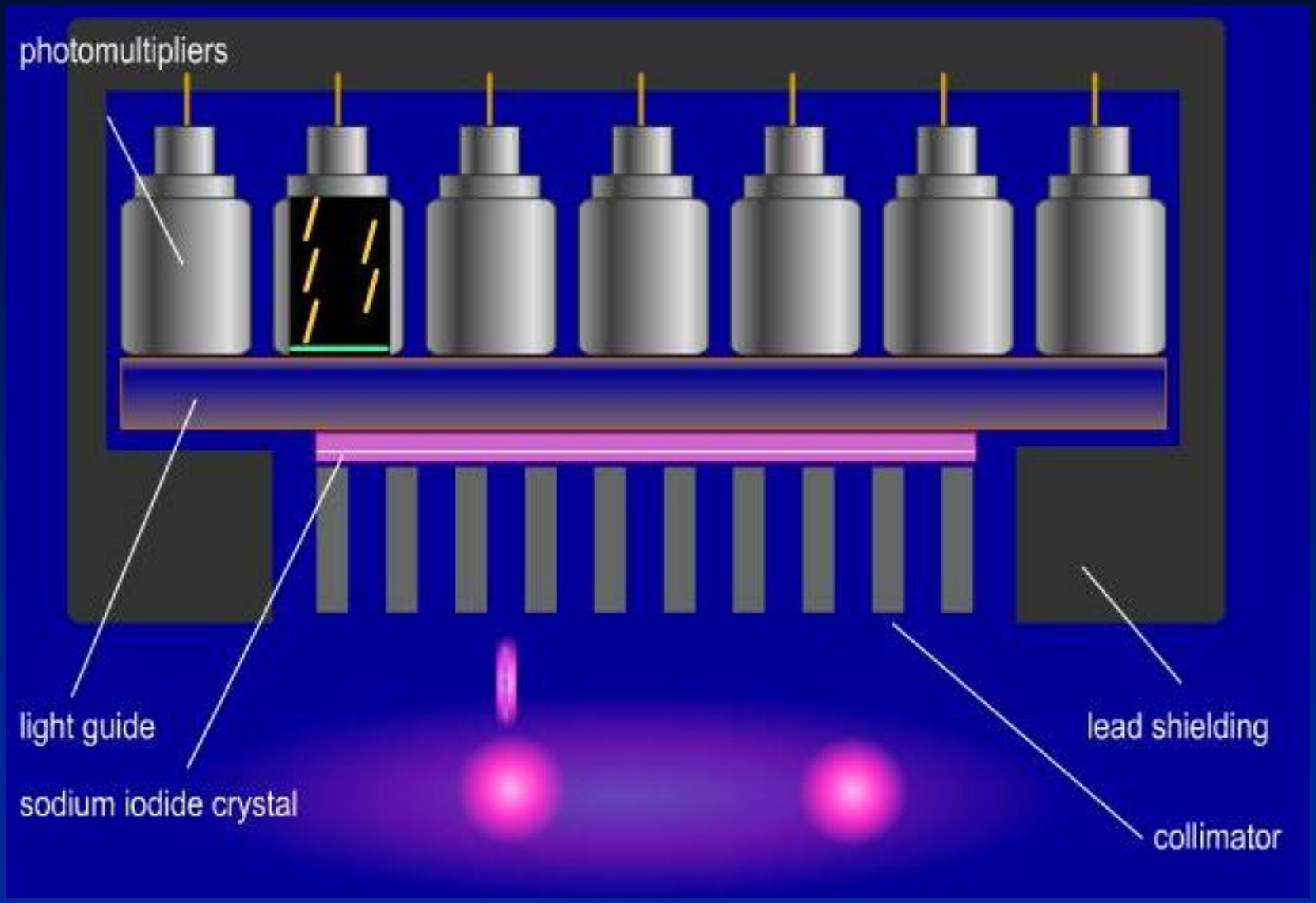

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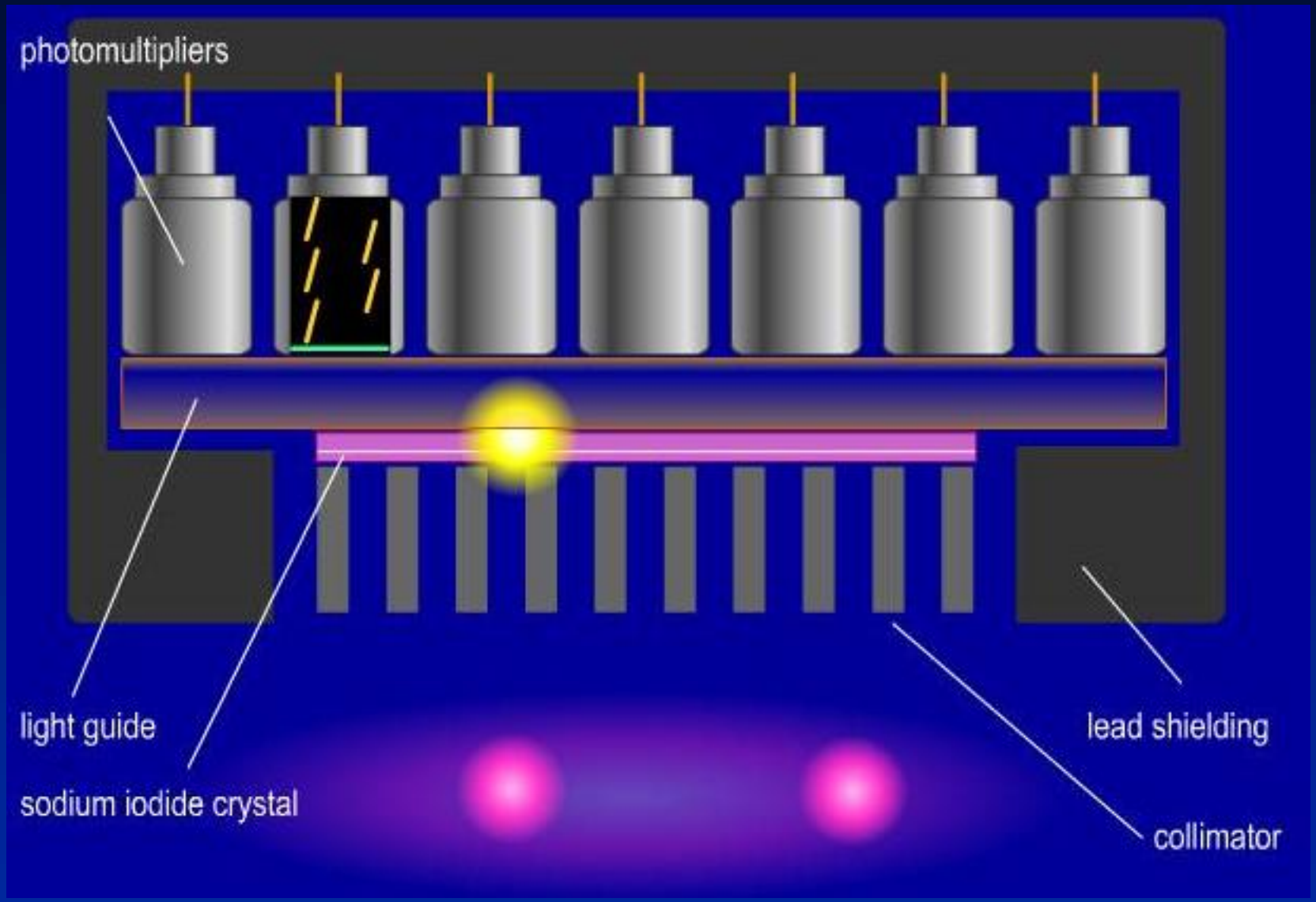

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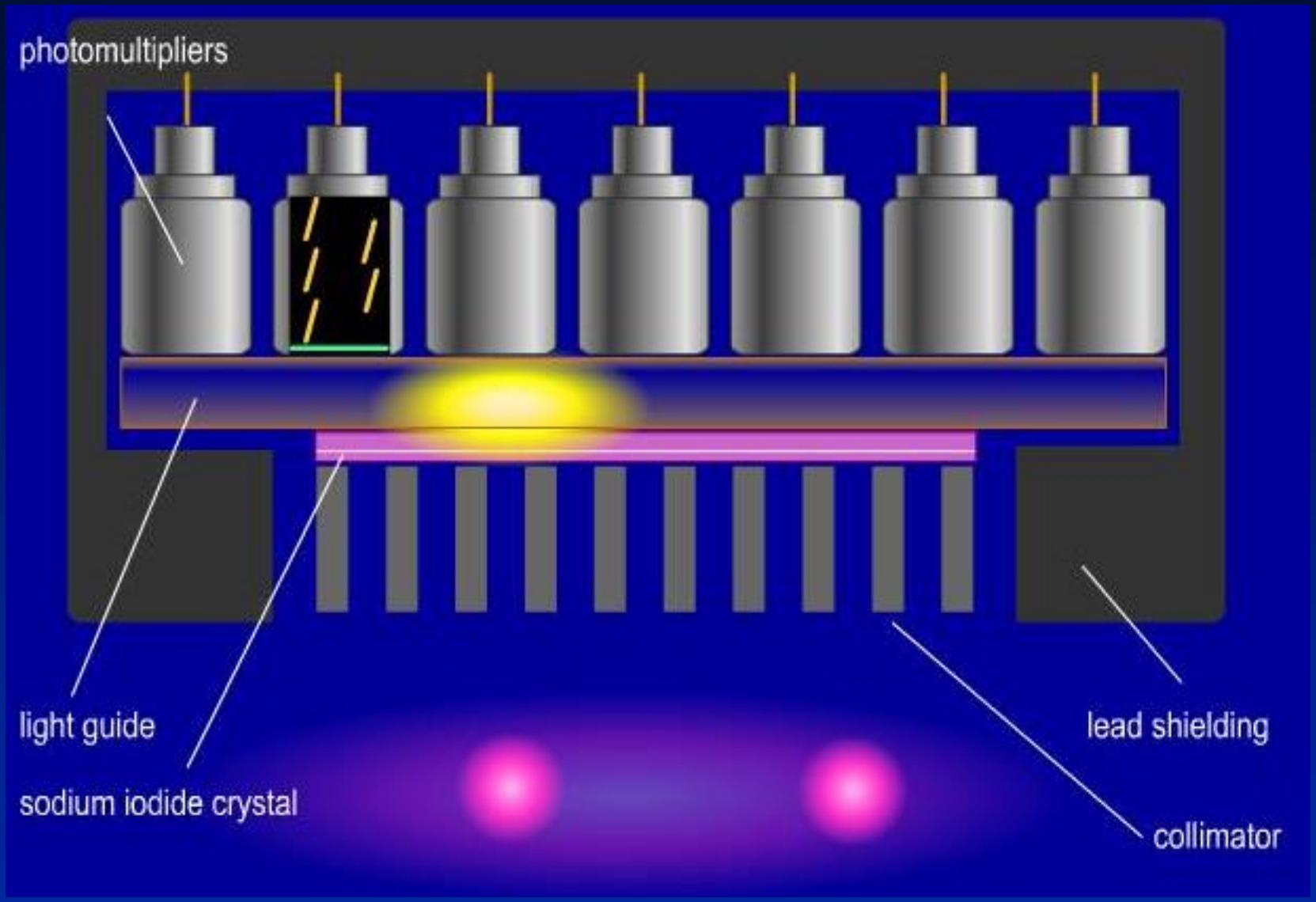

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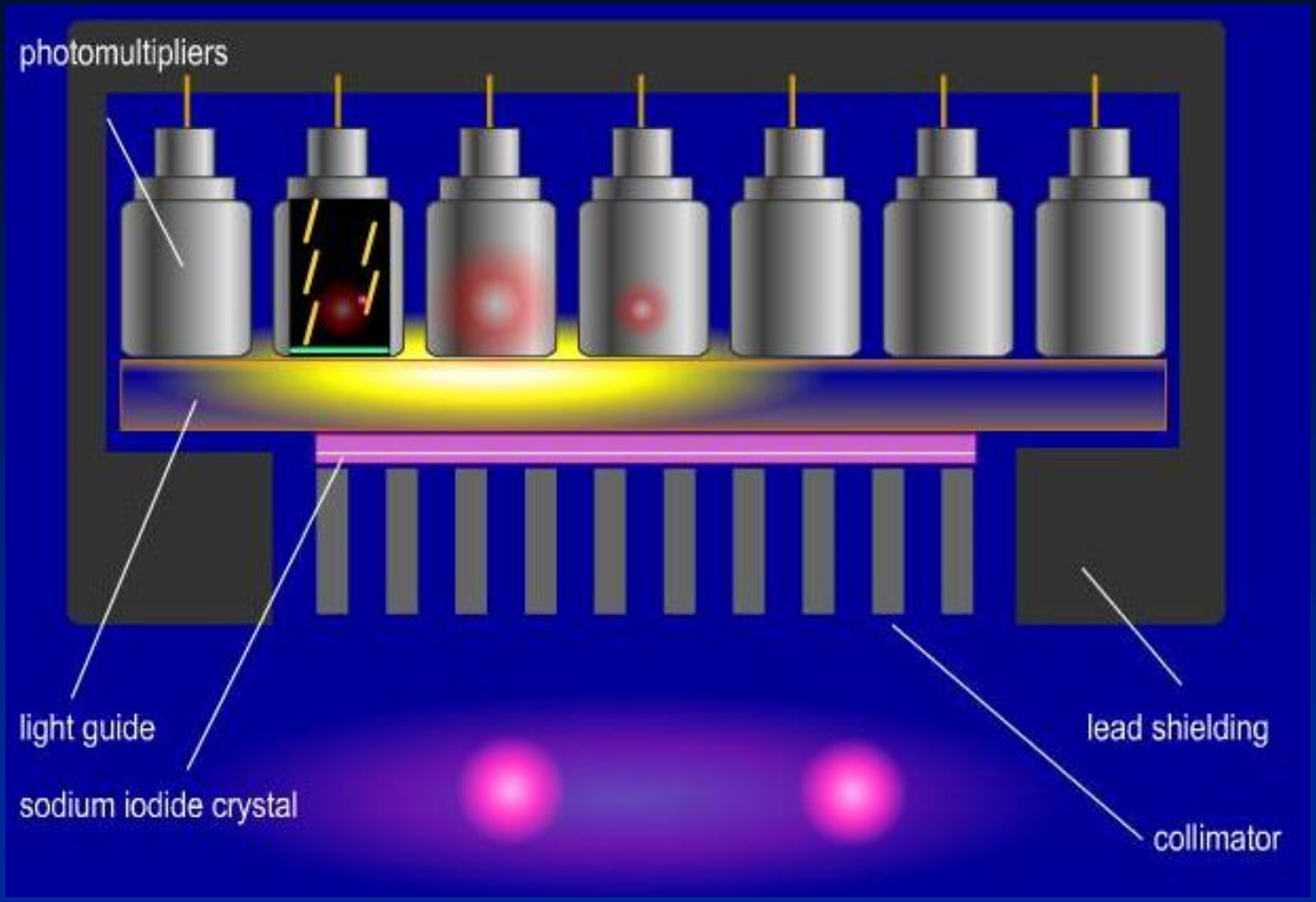
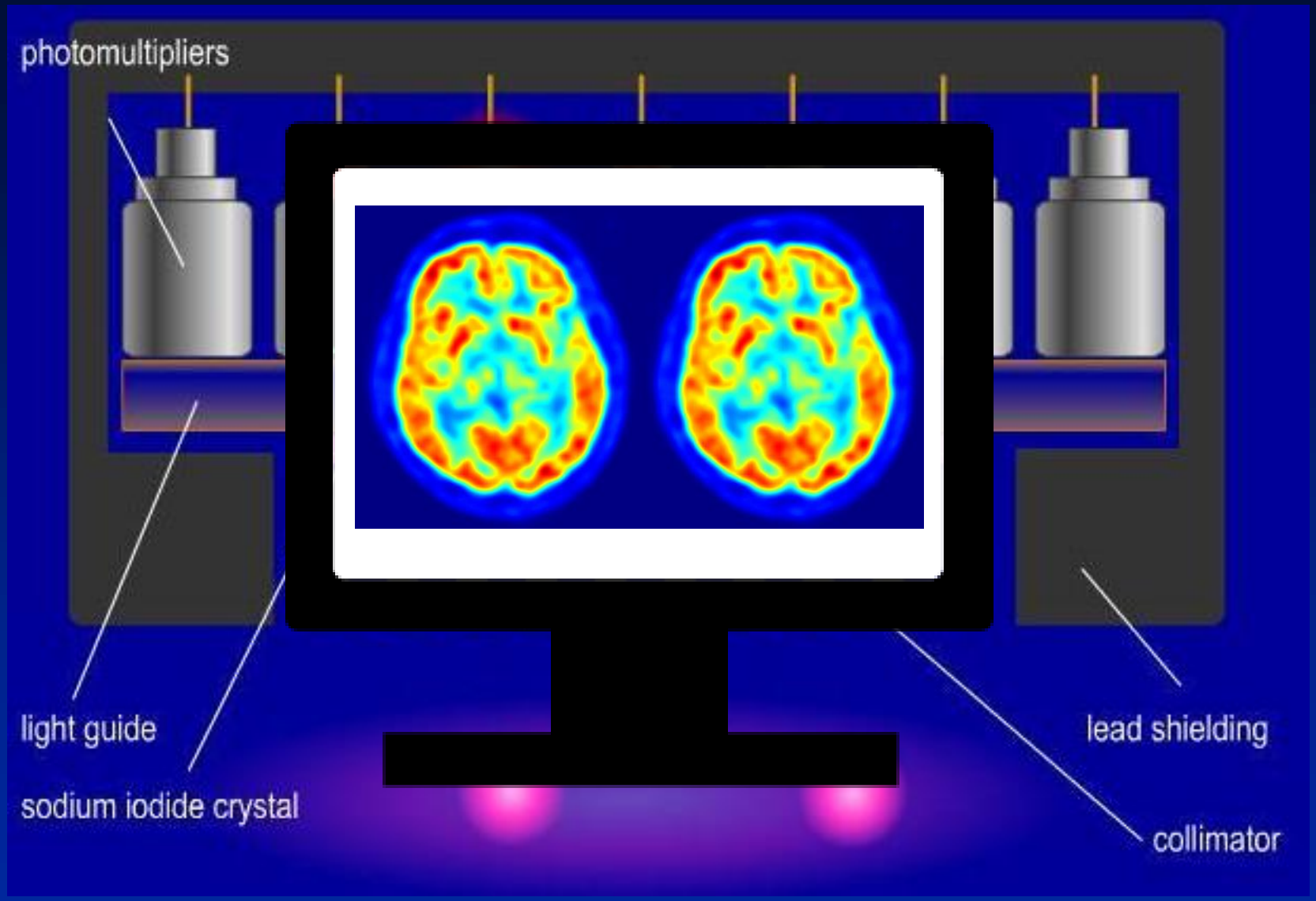


Gamma Camera = Images Gamma Emission



Nuclear Medicine: Diagnostic Principles

- The diagnostic radiotracer does not change the biology of the test subject
  - They do not harm patients
  - They do not change biochemistry they measure or pathophysiology they depict
- The diagnostic radiotracers distribute in proportion to the targeted volume
  - Change in the target volume is proportional to the changes in measured radioactivity

Hepatobiliary Scintigraphy

Traces the clearance of bilirubin into bile and tracks the biliary flow

Functional Liver Unit: Hepatic Lobule (wedge - 1/4th)

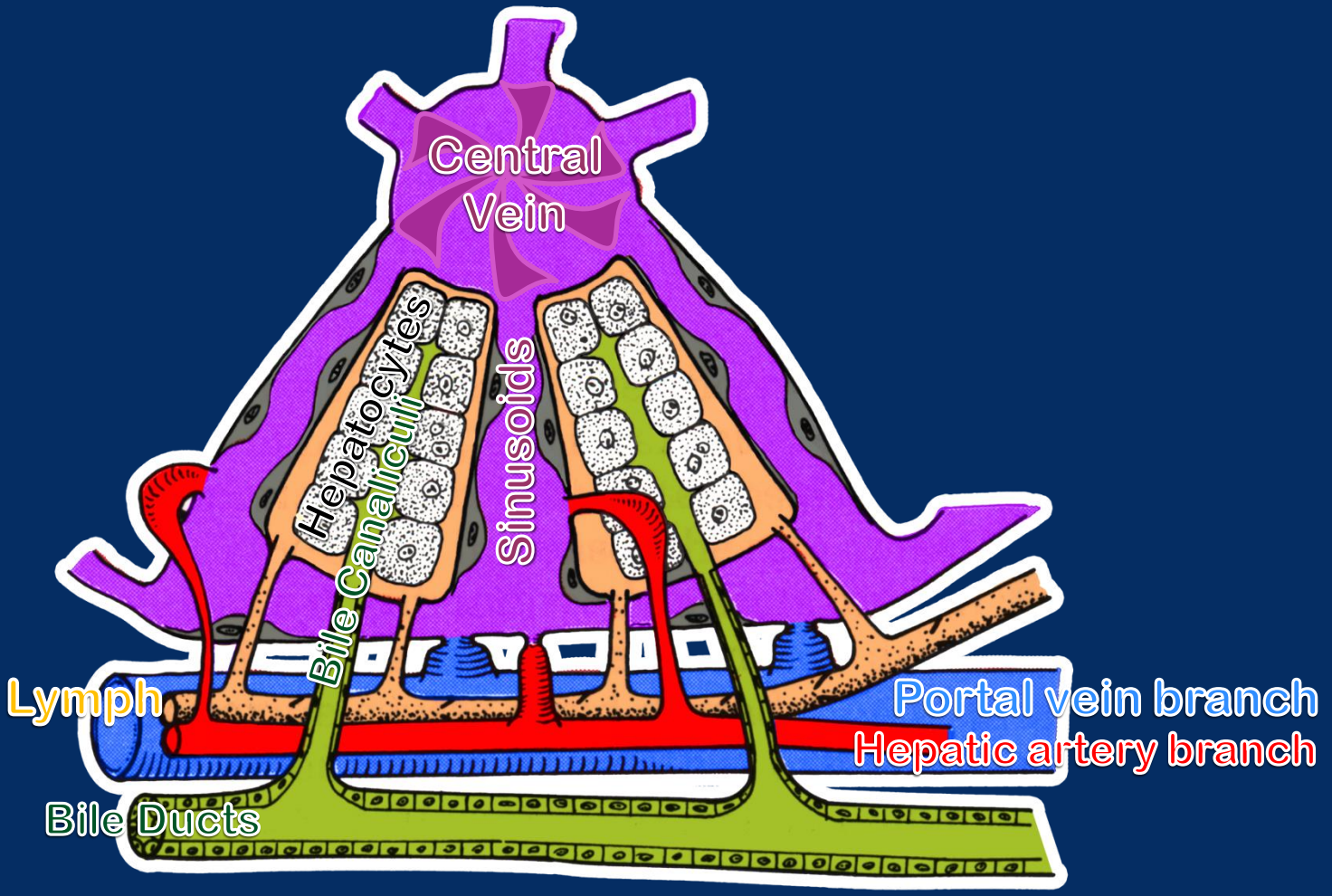


Illustration courtesy of Mark Tulchinsky, MD.

Radiotracer is Tc-99m-Mebrofenin

Tc-99m-Mebrofenin ( ) IV, 25% via hepatic artery (H. a.) and 75% via portal vein (P. v.)

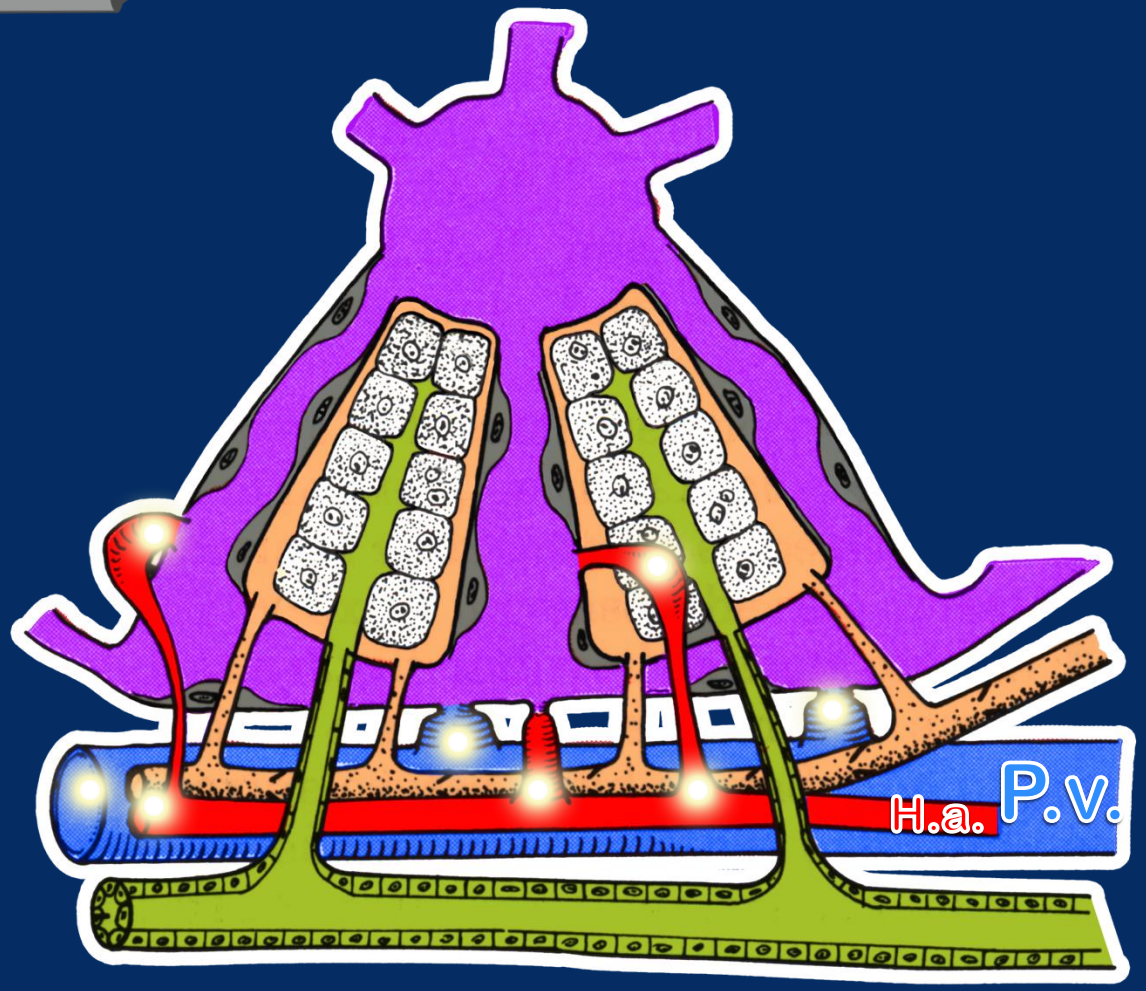


Illustration courtesy of Mark Tulchinsky, MD.

Uptake of Tc-99m-Mebrofenin

Mebrofenin( ) uptake is facilitated by organic anion transporting polypeptides 1B1 and 1B3. It is excreted into biliary canaliculi unchanged with bile, draining into to the bile ducts.

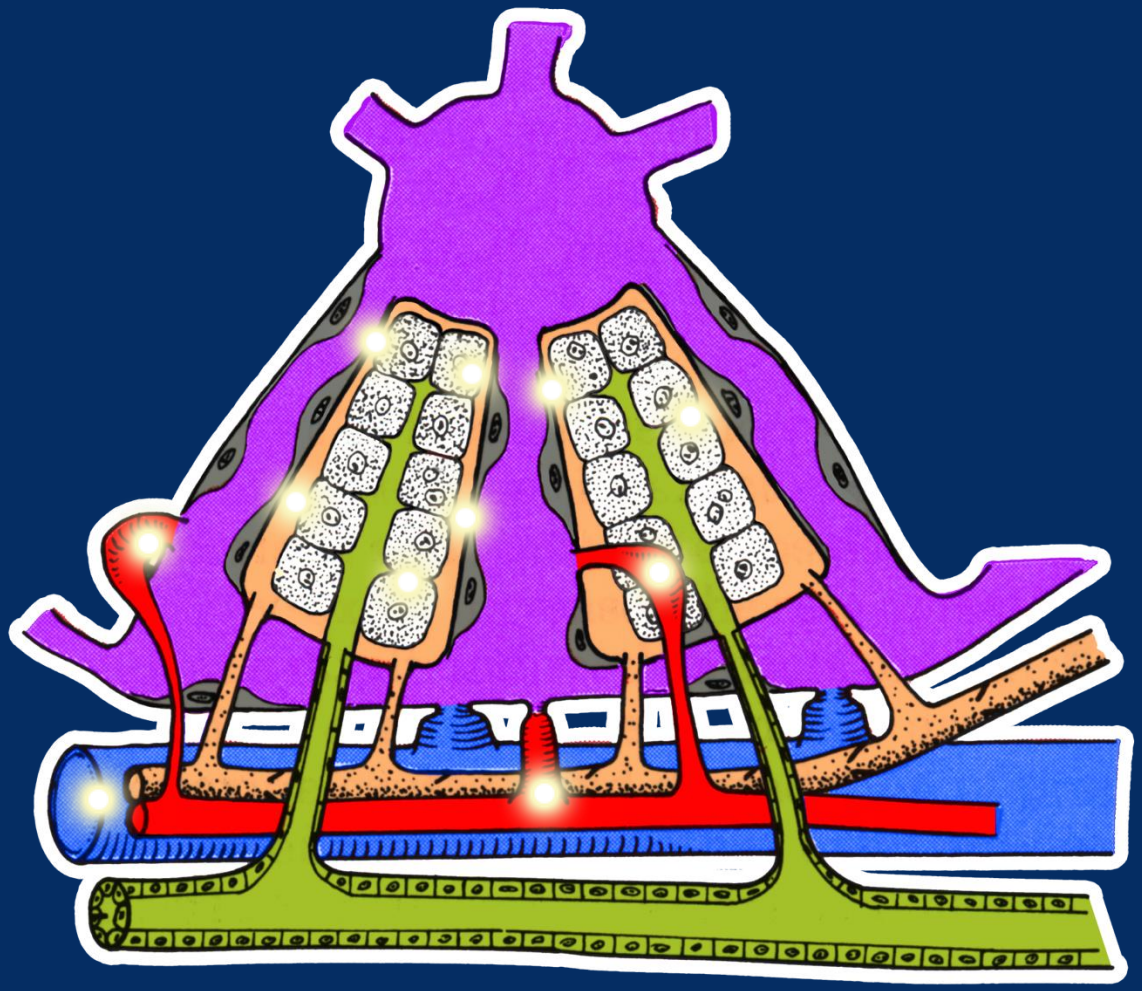
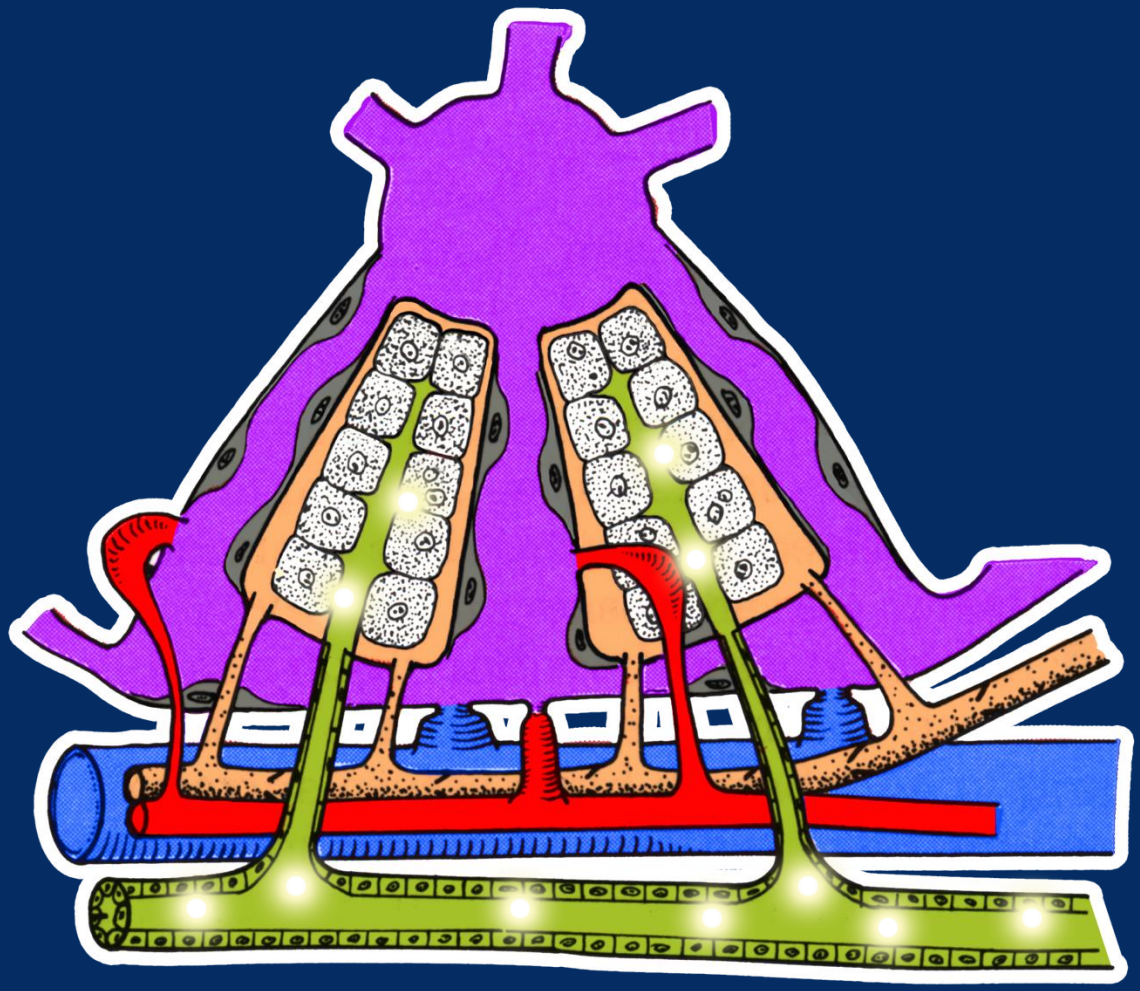


Illustration courtesy of Mark Tulchinsky, MD.

Excretion of Tc-99m-Mebrofenin

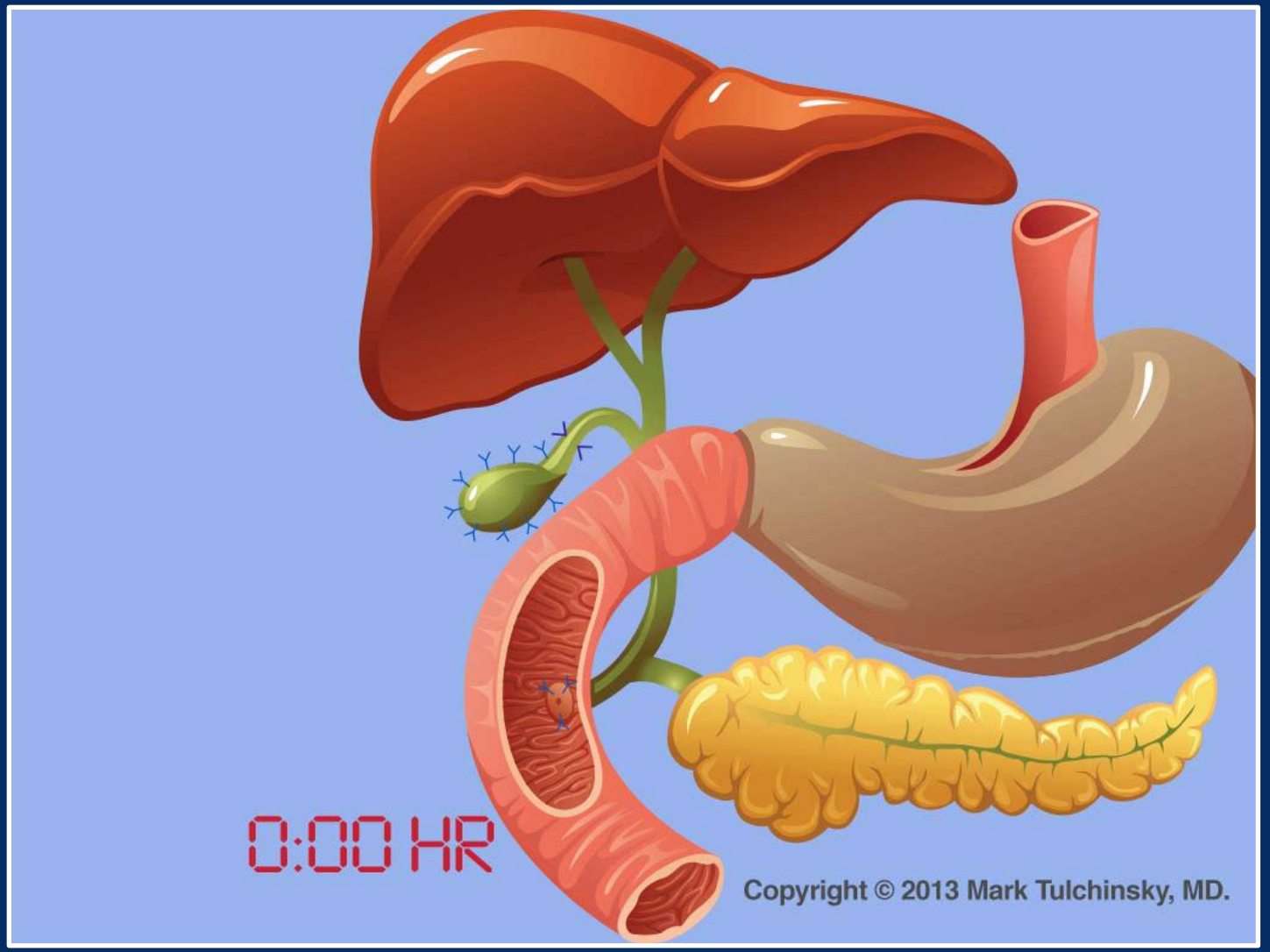
Mebrofenin( ) excretion is facilitated by multidrug resistance-associated protein 2.



Radiopharmaceutical extracted by hepatocytes and transported without modification.

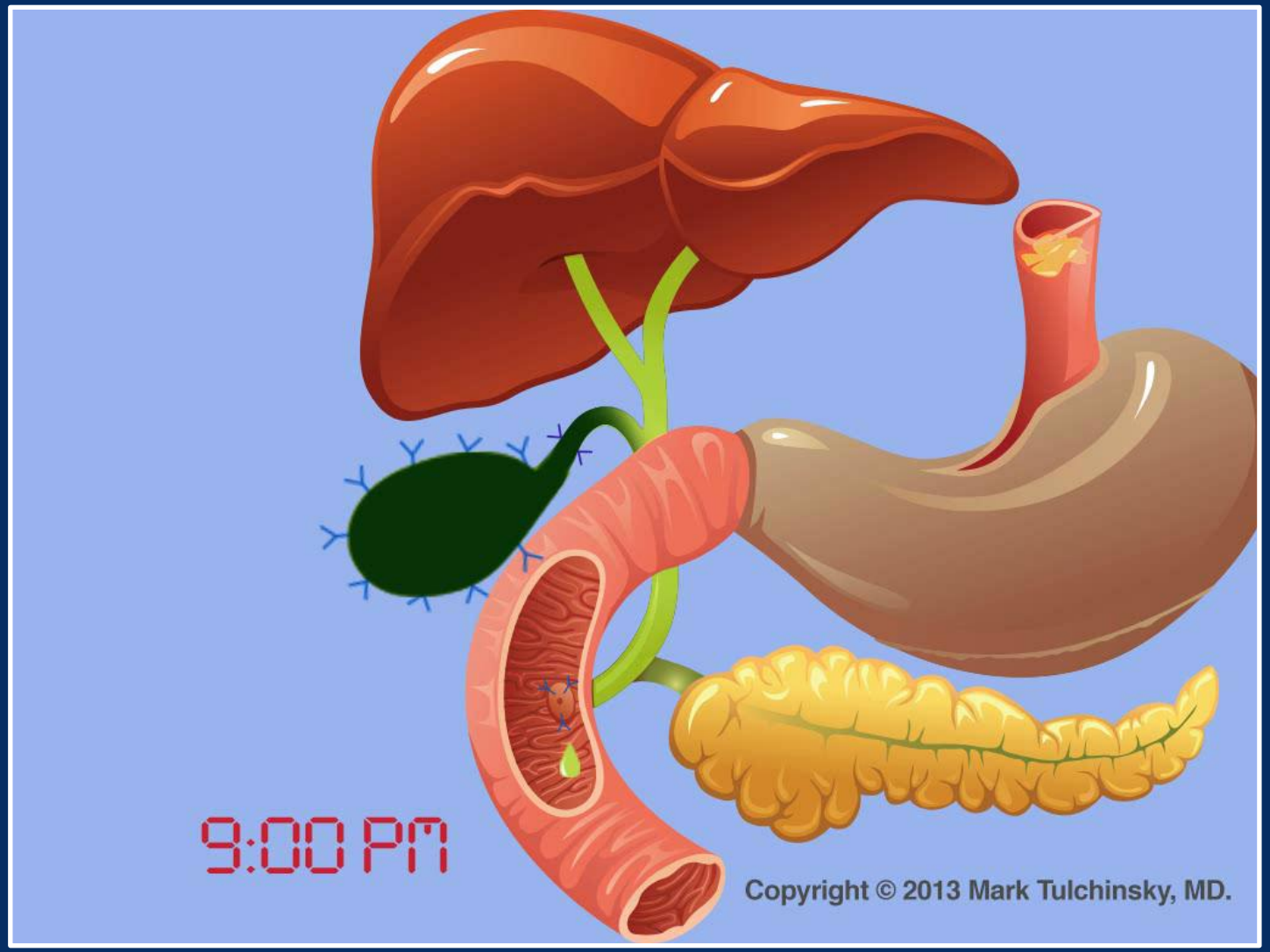
Illustration courtesy of Mark Tulchinsky, MD.

The Gallbladder in Fasting State: Accommodation of Incoming Bile

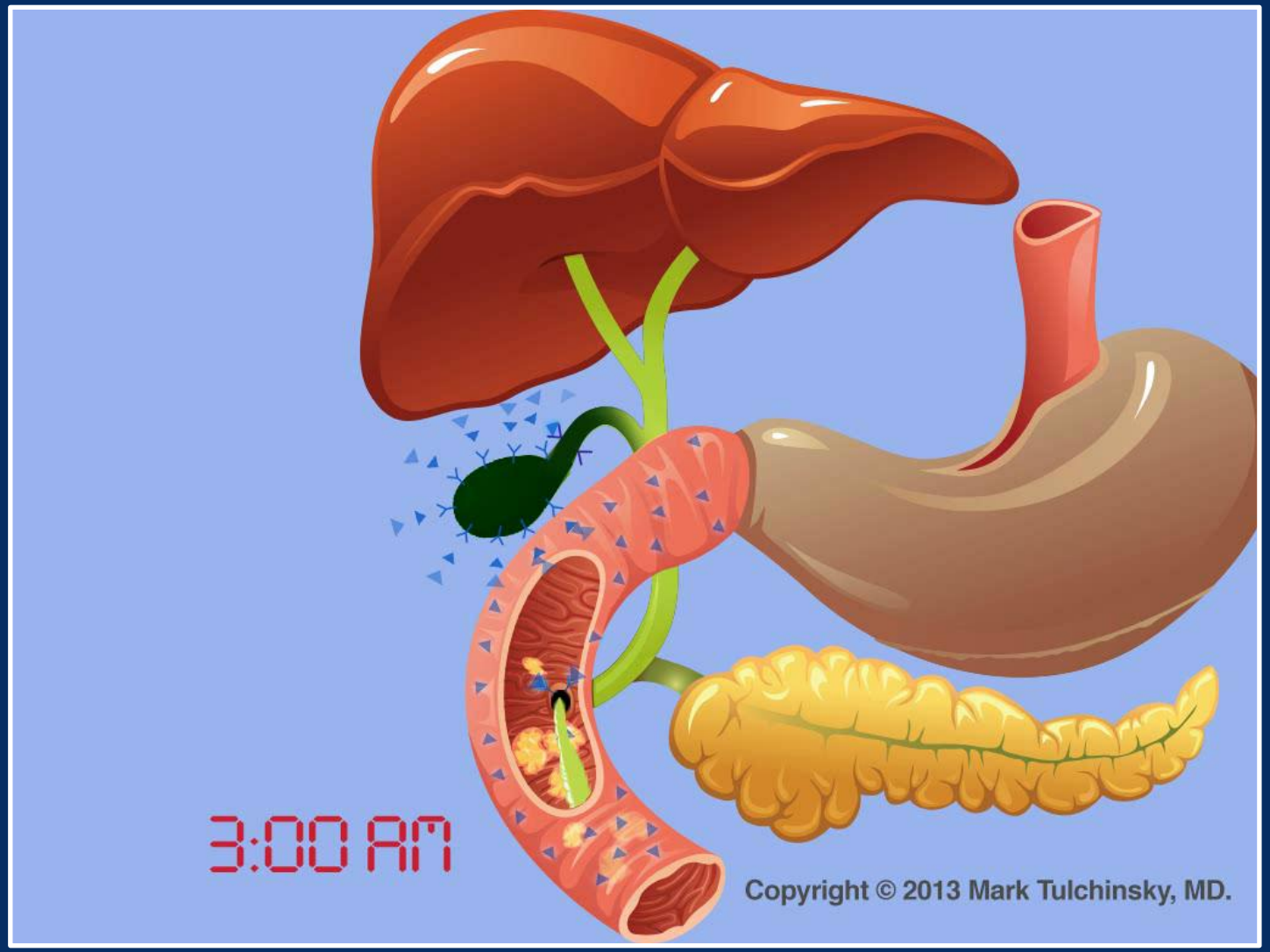


The Gallbladder in Prolonged Fasting State (>24 Hours)

Postprandial Gallbladder: Set-up for a False-Positive

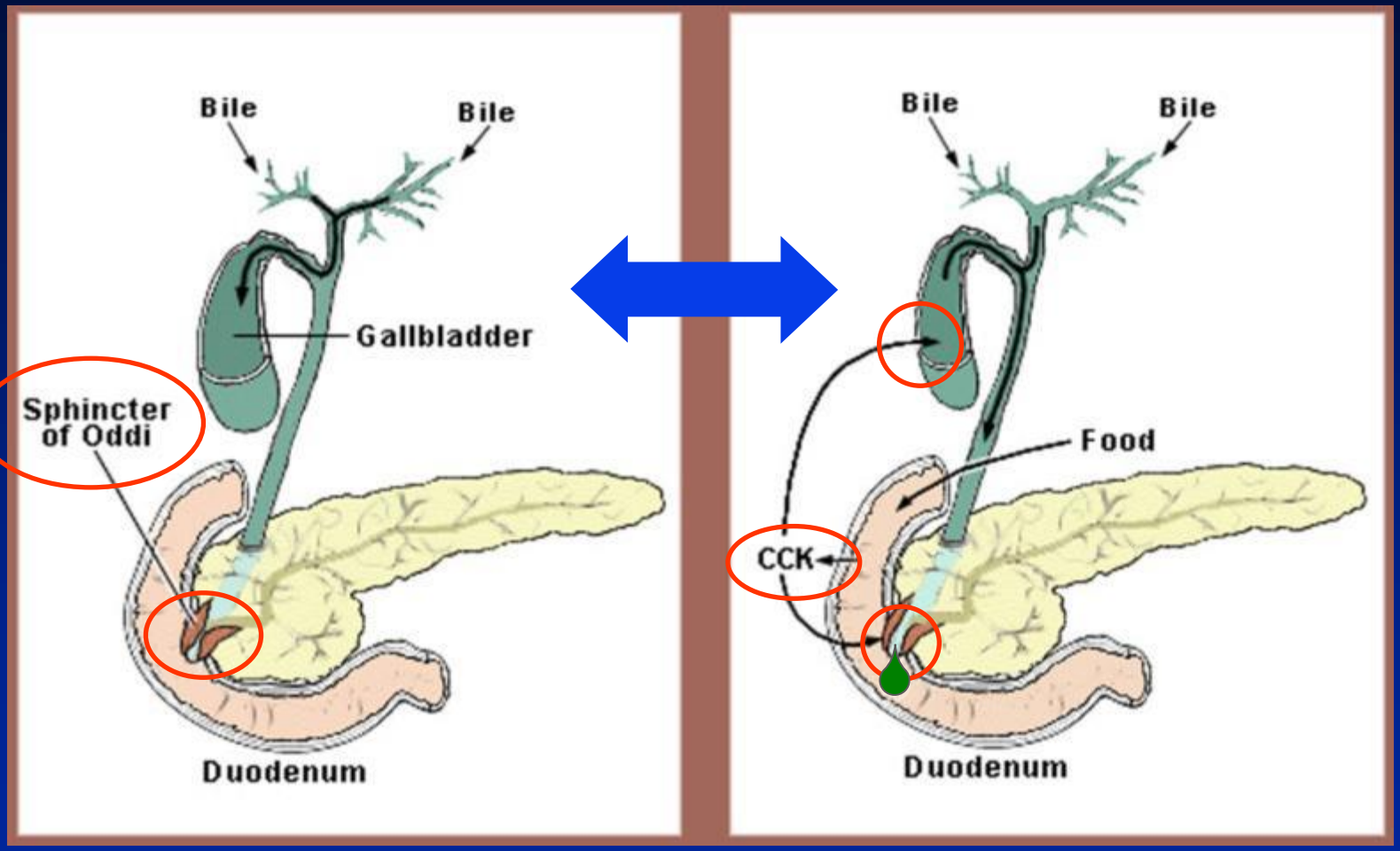


Postprandial Refilling of Gallbladder



Fasting

Postprandial or Post-CCK



Costoff A. Gastrointestinal Physiology: Biliary Secretion and Excretion. *http://www.lib.mcg.edu/edu/eshuphysio/program/section6/6ch5/s6ch5_12.htm*

Patients With Chronic Abdominal Pain and Gallbladder Dysfunction

Why Is Diagnosis So Difficult?

- Lack of a clear definition of biliary pain[1]
- Nonspecific nature of the symptom complex[1]
- Limited understanding of the natural history and pathophysiology of chronic biliary-type abdominal pain[1]
- Lack of standardization in performance of CCK-CS in terms of CCK dose, duration of administration, and definition of normal values[1, 2]
- Low percentage of US practices using the recommended CCK infusion protocol[2]
- Inappropriate referral for testing[1]

1. Dibaise JK, et al. *Clin Gastroenterol Hepatol.* 2011;9(5):376-384.
2. Tulchinsky M, et al. Poster presented at: 2012 Annual Meeting of the Society of Nuclear Medicine and Molecular Imaging; June 9-13, 2012; Miami, FL. Poster 2117. Abstract available in: *J Nucl Med.* 2012;53(suppl 1):2117.

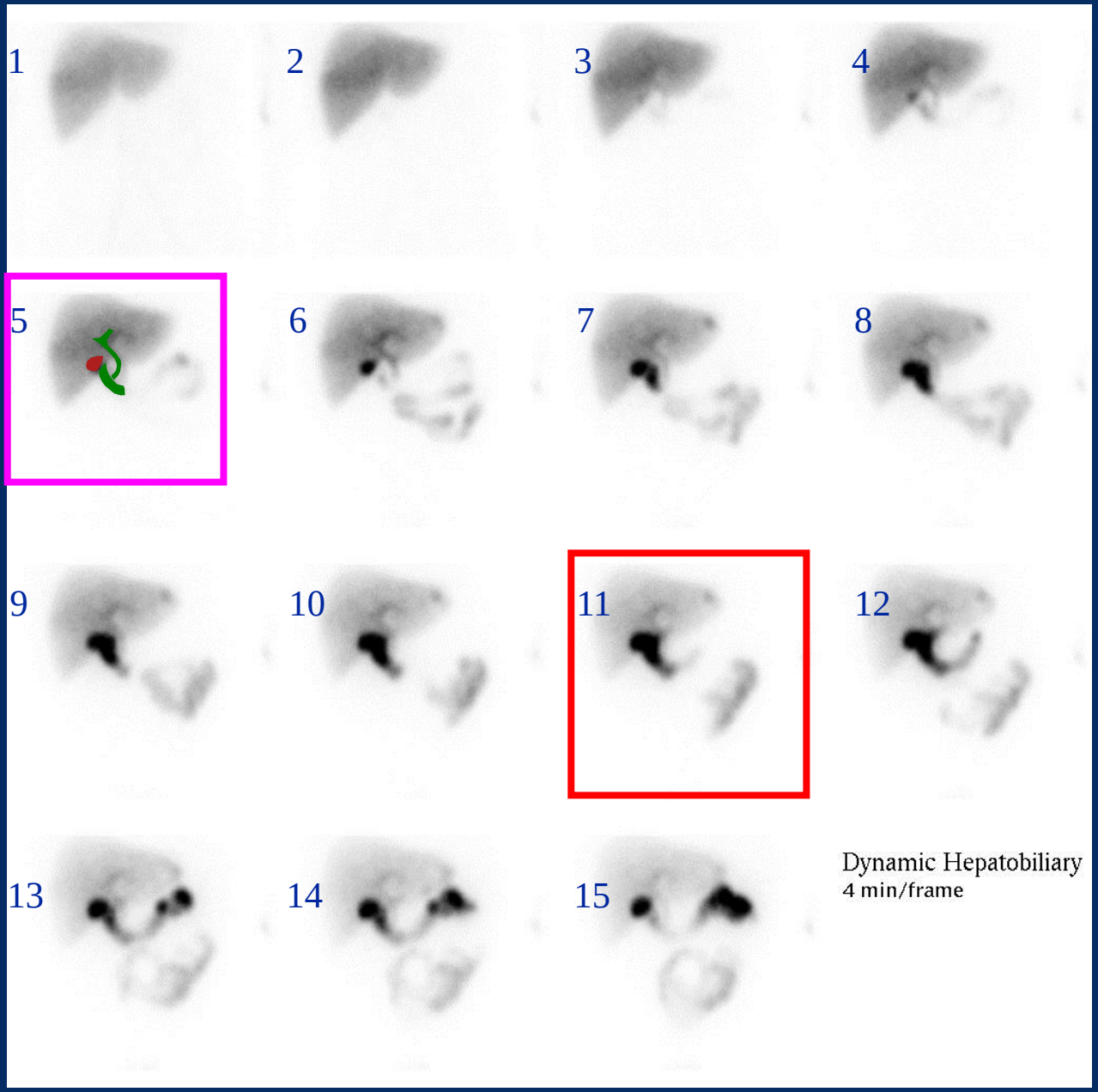
Chronic GB/Biliary Disease: Spectrum of Conditions

Acalculous

- **Functional GB disorder**
  - **"Biliary dyskinesia"**
  - **"Gallbladder dyskinesia" (surgeons' label)**
  - **"Chronic acalculous cholecystitis" or "acalculous cholecystopathy"**
  - **"Chronic acalculous biliary disease"**
  - **"Acalculous biliary disease"**
  - **"Cystic duct syndrome"**
  - **"GB spasm"**
- **Sphincter of Oddi dysfunction**
  - **"Biliary dyskinesia" (gastroenterologists' label)**

Calculous

- **Chronic calculous cholecystitis**

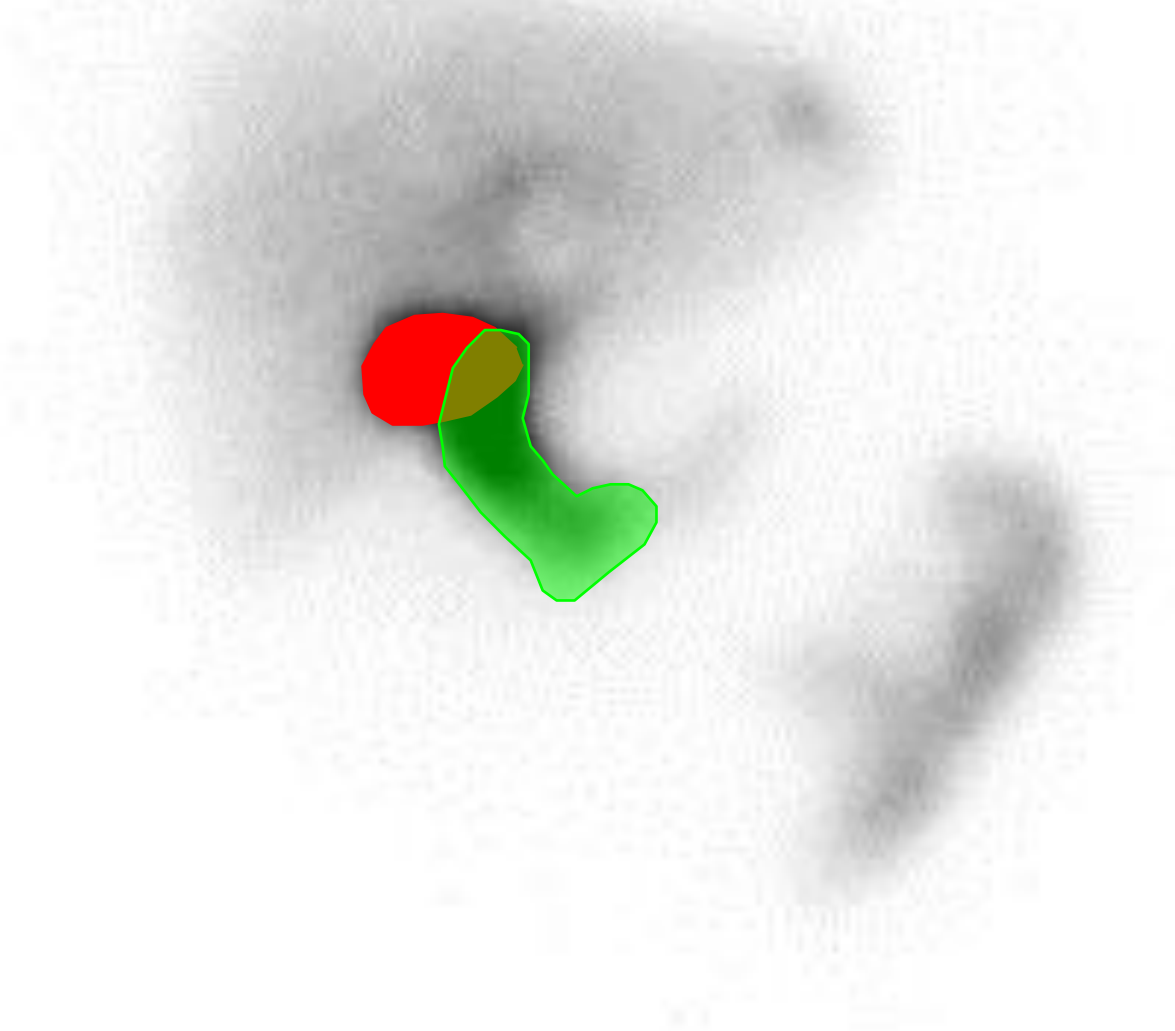


Images courtesy of Mark Tulchinsky, MD.

Anterior View

Case 1

In the anterior view, the activity in the duodenum often contributes to (interferes with) activity in the gallbladder region!



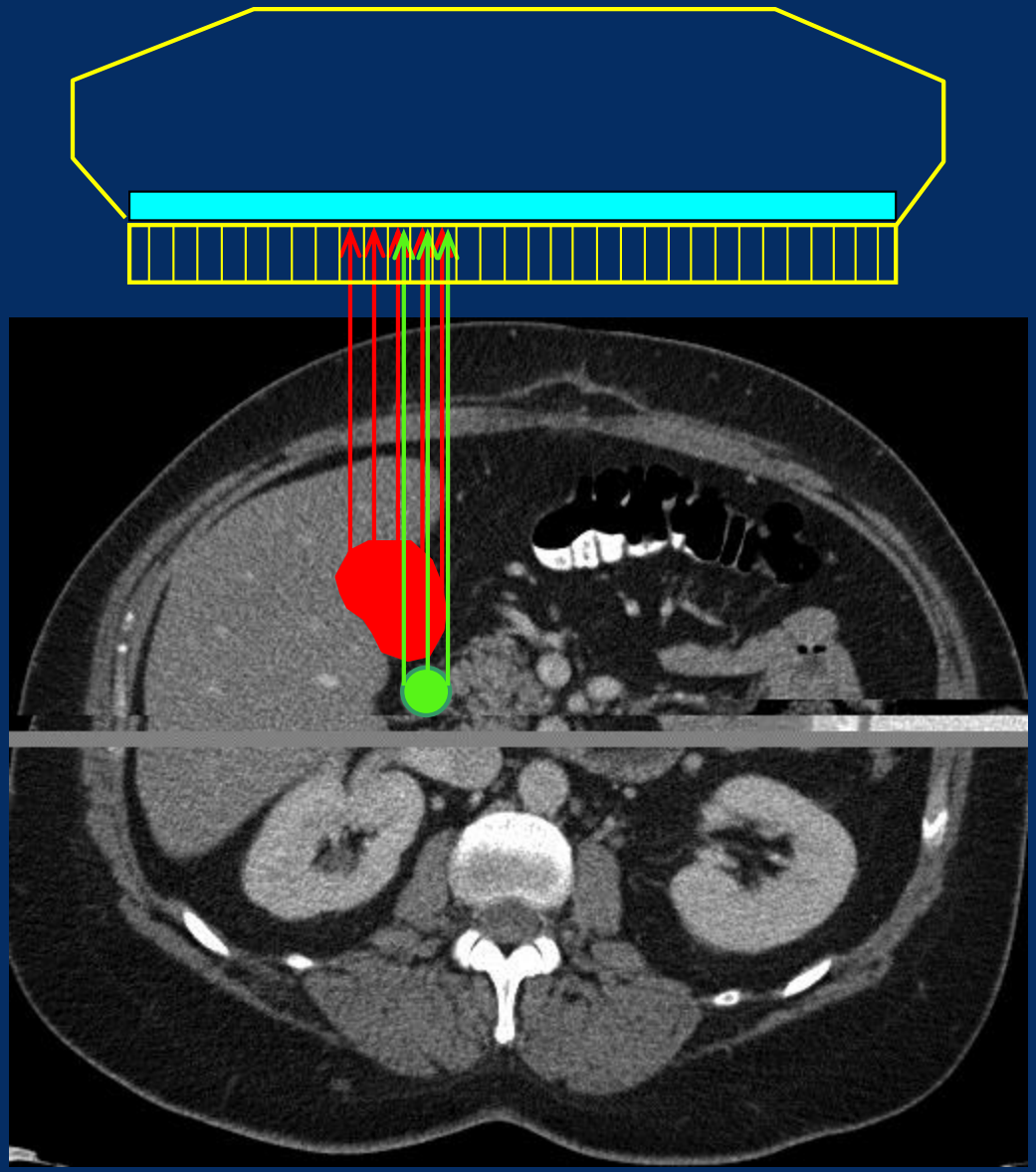
Anterior View

Image courtesy of Mark Tulchinsky, MD.

Anterior View

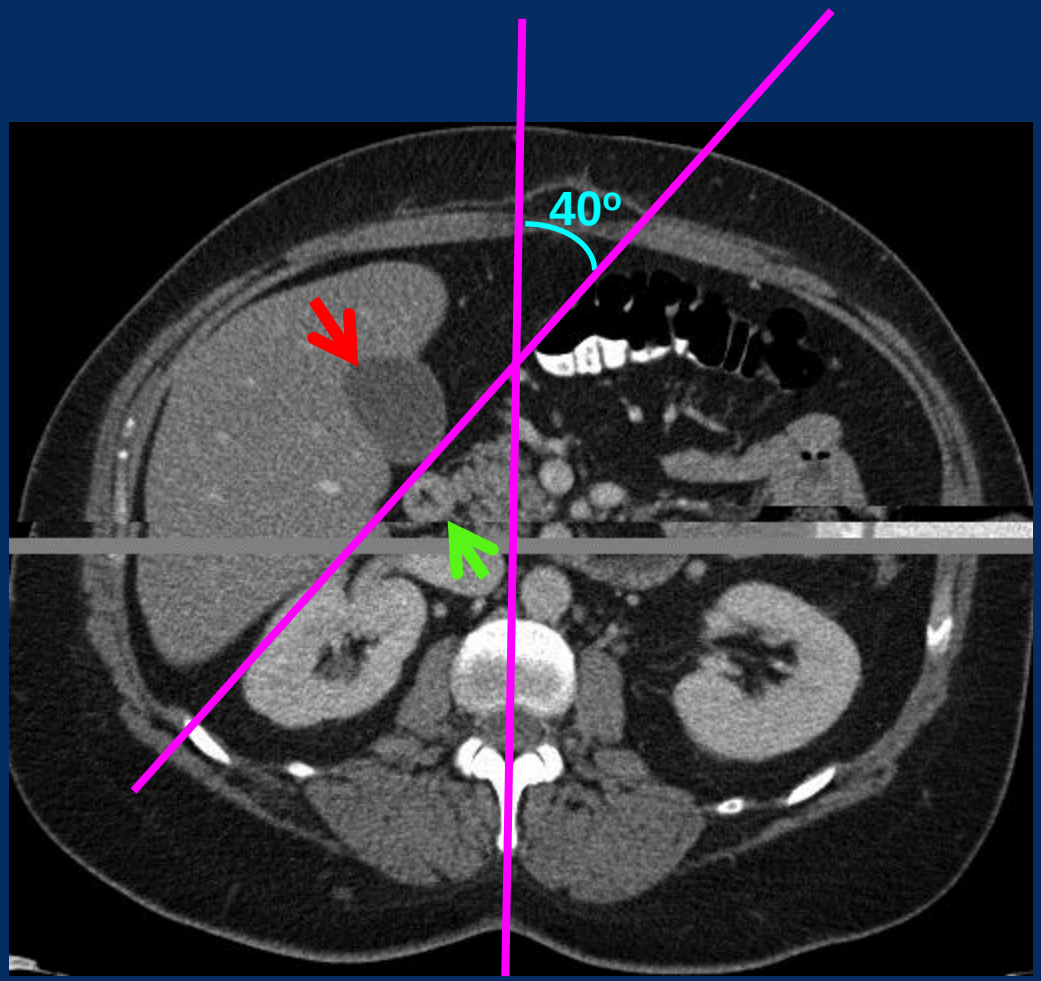
Image courtesy of Mark Tulchinsky, MD.

Case 1



Anterior View

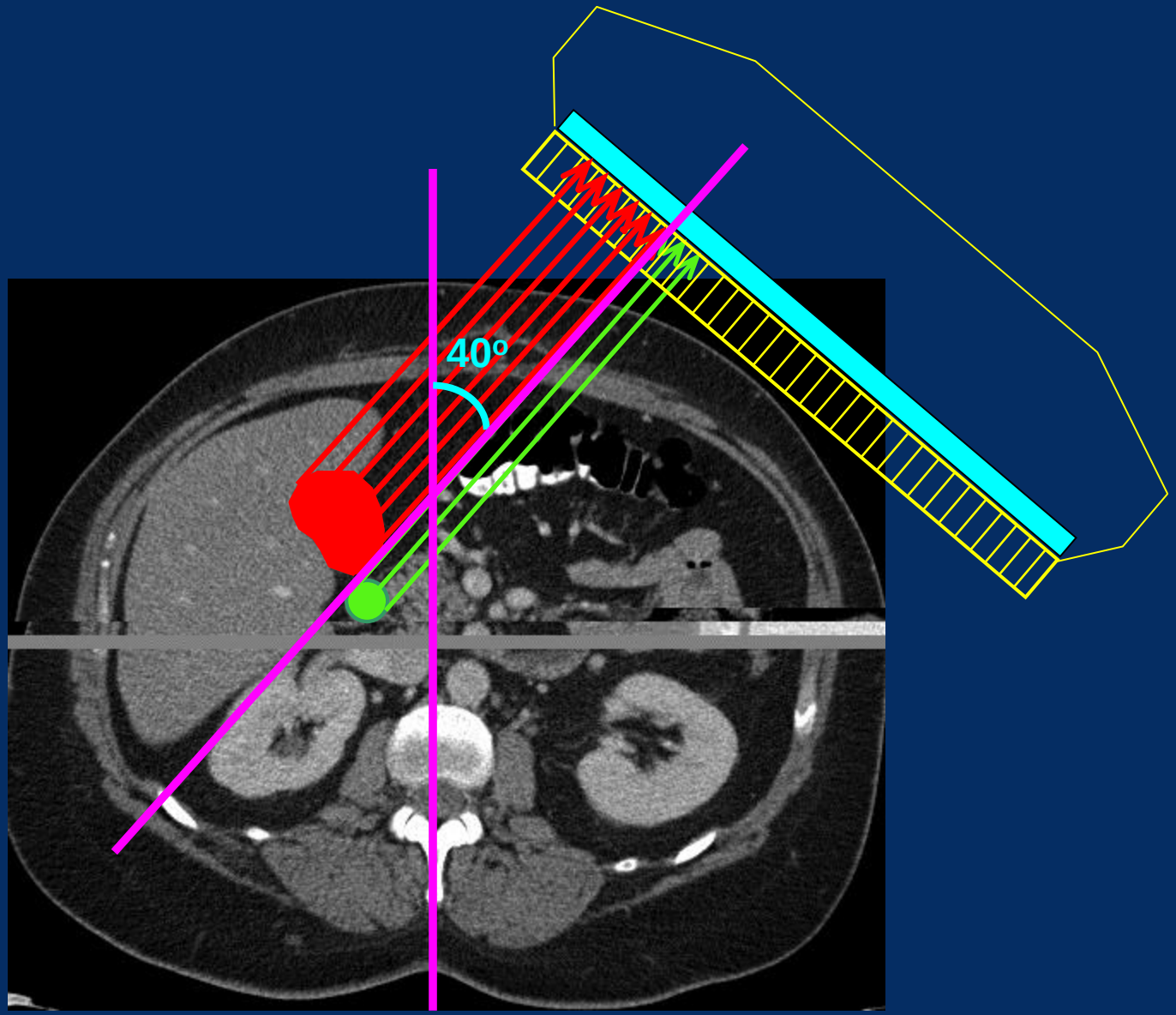
Image courtesy of Mark Tulchinsky, MD.



LAO view separates the GB from duodenal activity –

makes good anatomical sense!

Image courtesy of Mark Tulchinsky, MD.

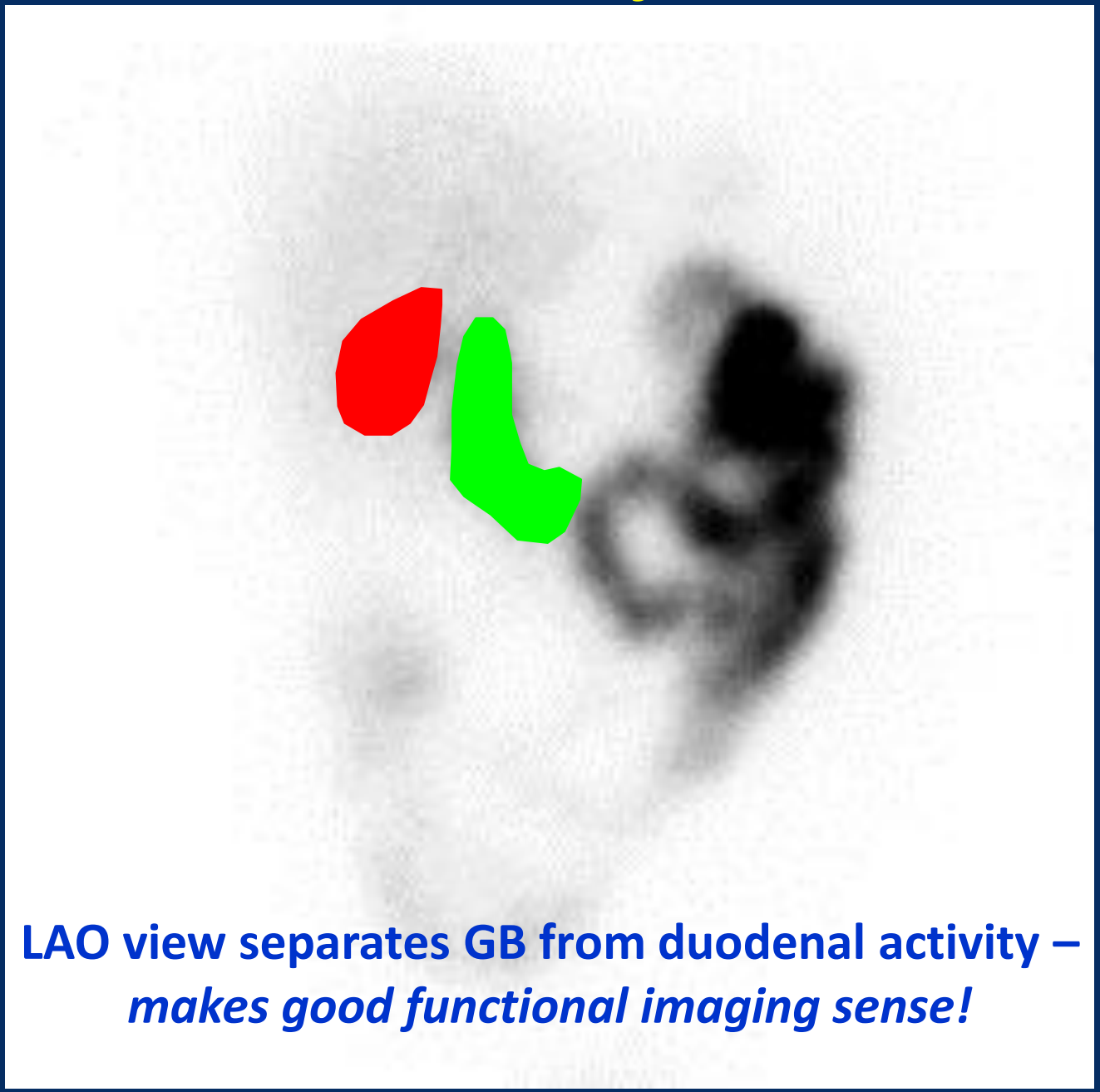


LAO view separates GB from duodenal activity –

makes good anatomical sense!

Image courtesy of Mark Tulchinsky, MD.

40° LAO Projection



LAO view separates GB from duodenal activity –
makes good functional imaging sense!

Image courtesy of
Mark Tulchinsky, MD.

Sincalide-Stimulated Cholescintigraphy: A Multicenter Investigation to Determine Optimal Infusion Methodology and Gallbladder Ejection Fraction Normal Values

All 60 normal volunteers – GB viz by 60 min x 3! Therefore, if there is GB non-viz by 60 min = abnormal GB function, test completed!

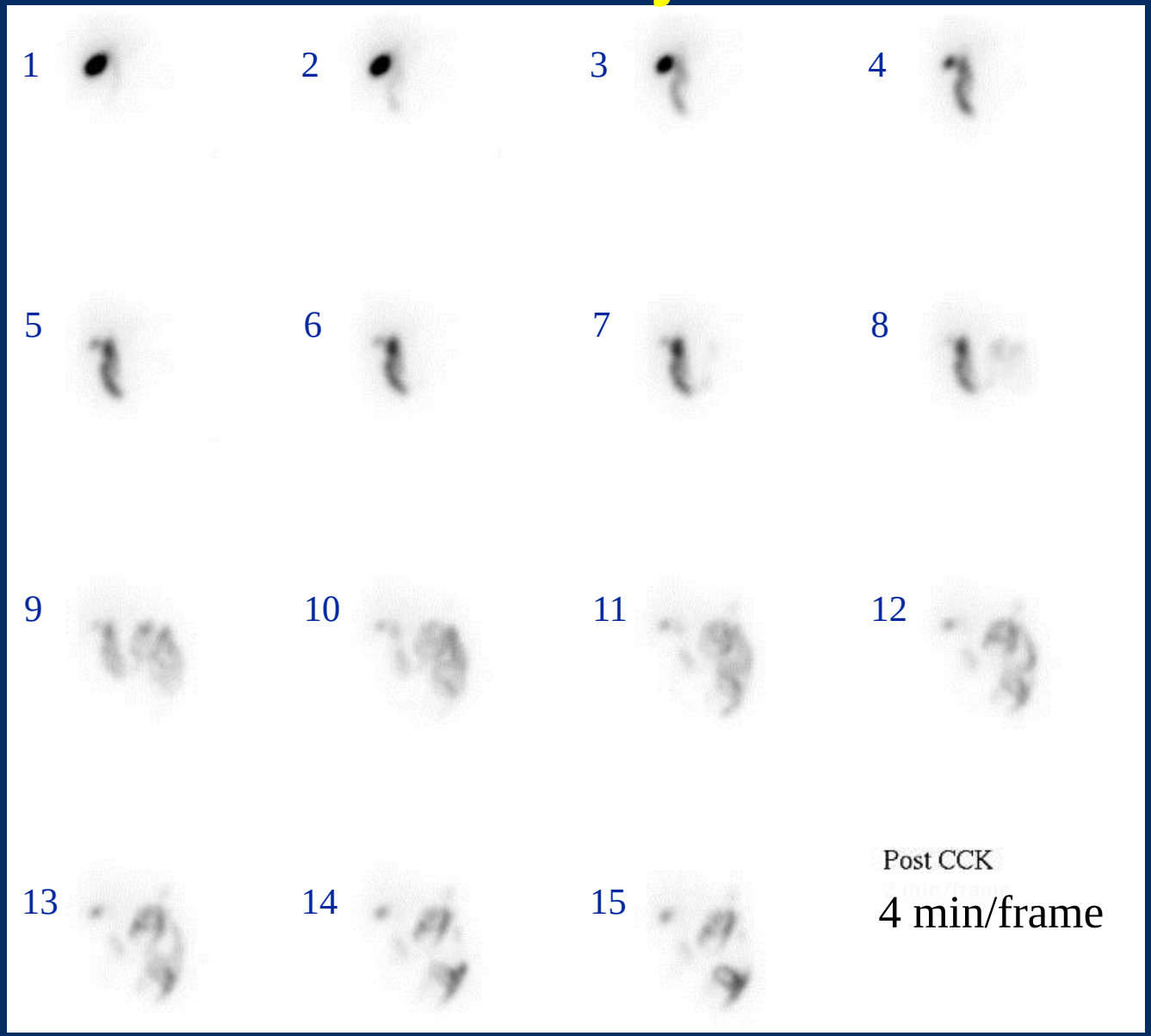
Min/μg per kg	GBEF (M±S.D.)	GBEF Range	GBEF<35%	CV(%)
15/0.02	56.9±29.4%*	-2 to 98%	16/60 (27%)	52%
30/0.02	70.9±24.5%*	8 to 99%	6/60 (10%)	35%
60/0.02	84.3±15.5% *	38 to 100%	0/60	19%

* Significantly different from other 2 infusion rates, $p < 0.0001$

- 60 min sincalide infusion is the most specific test for GB function
- GBEF ≥ 38% is normal

Ziessman HA, Tulchinsky M, Lavely WC, et al. Sincalide-stimulated cholescintigraphy: a multicenter investigation to determine optimal infusion methodology and gallbladder ejection fraction normal values. J Nucl Med. 2010;51:277-281.

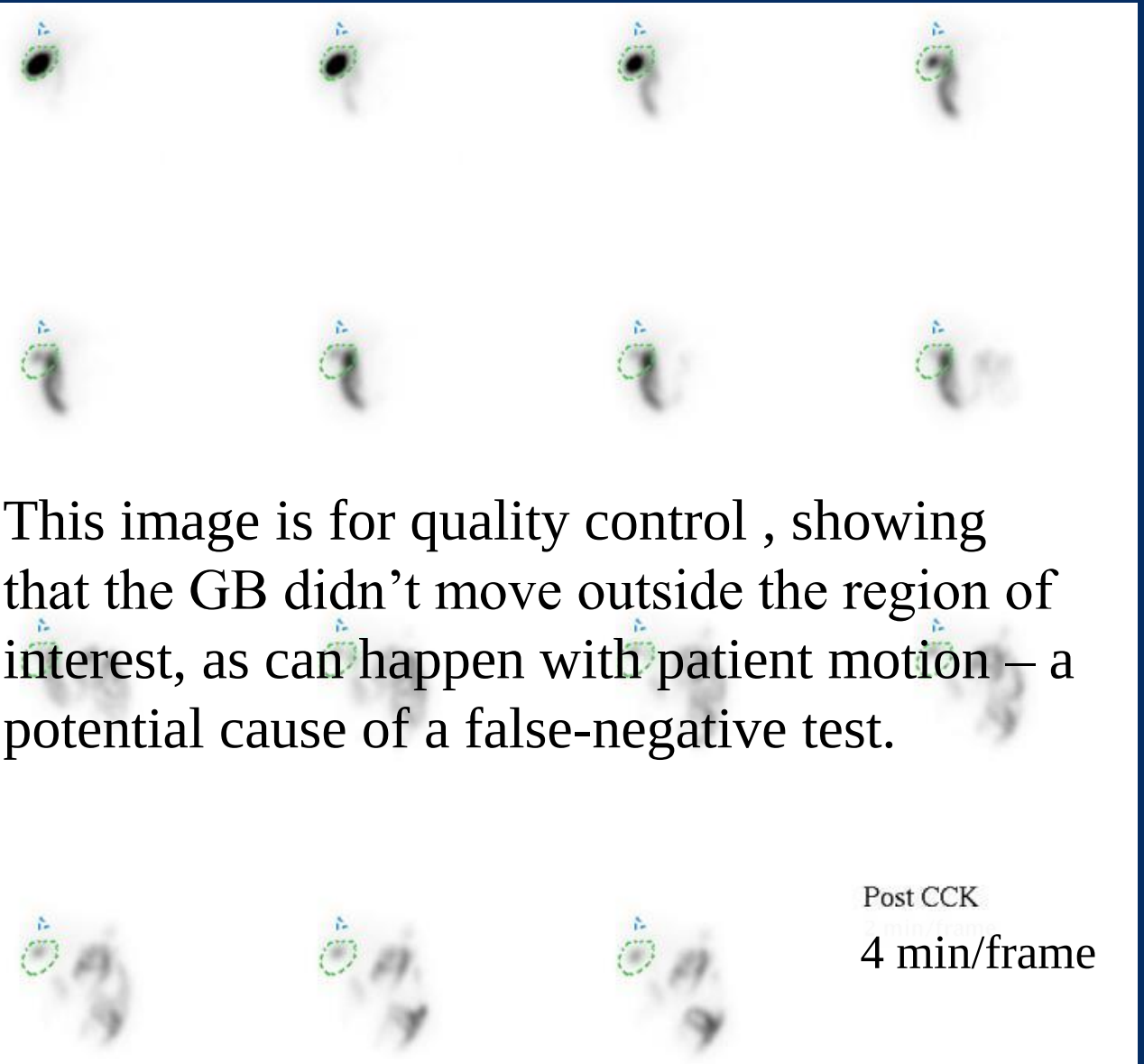
40º LAO Projection



Images courtesy of
Mark Tulchinsky, MD.

Case 1

40º LAO Separates GB From Duodenal Activity



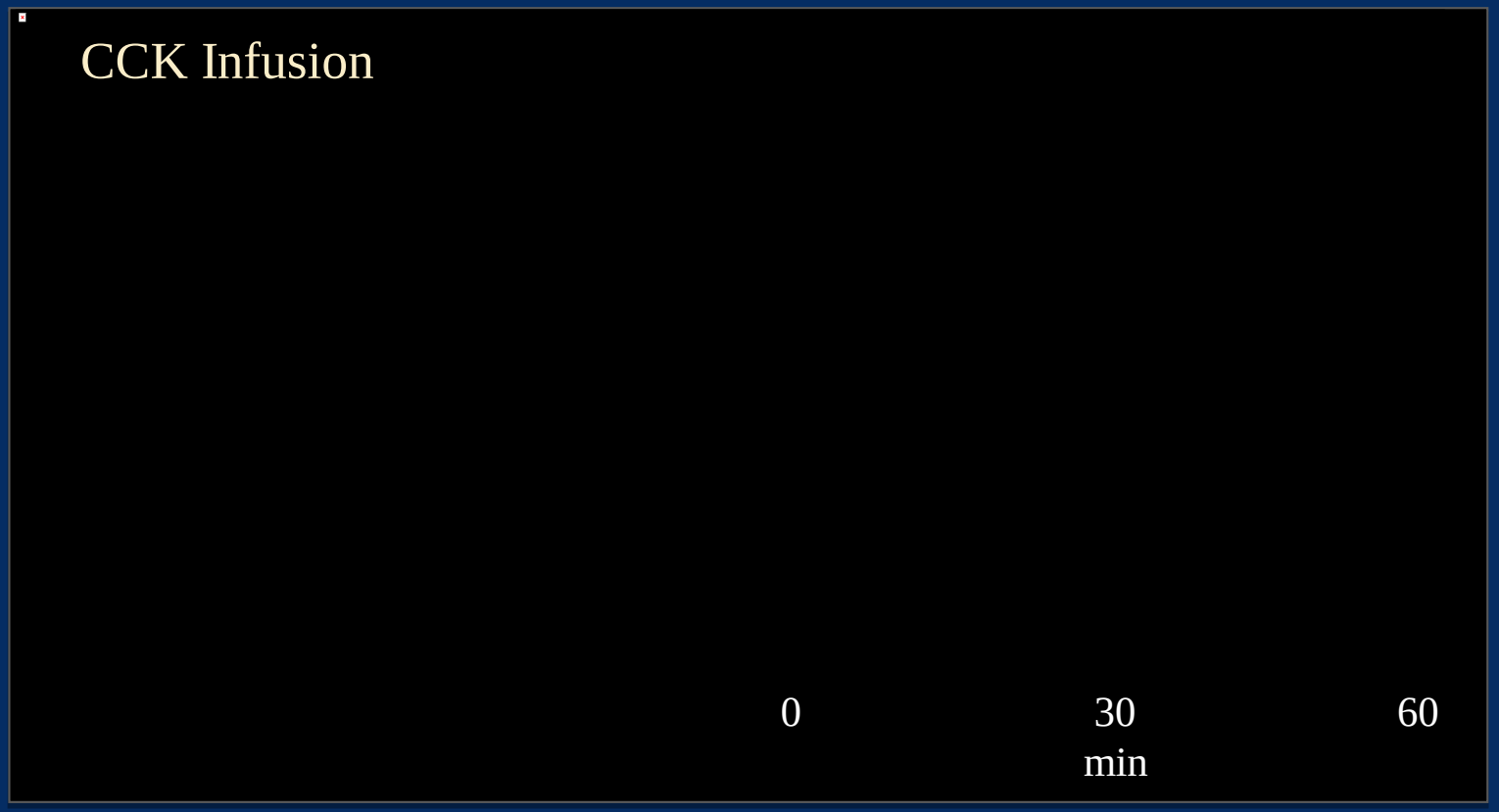
This image is for quality control , showing that the GB didn't move outside the region of interest, as can happen with patient motion – a potential cause of a false-negative test.

Post CCK

4 min/frame

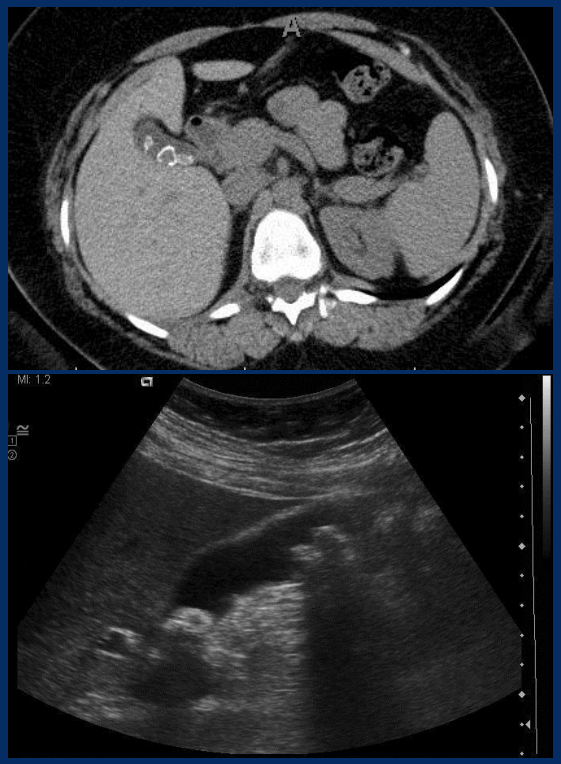
Images courtesy of Mark Tulchinsky, MD.

Impression: Normal GB Function, Normal Study



Images courtesy of
Mark Tulchinsky, MD.

45 y/o female with several years of abd/p, most severe in RUQ, cramps, diarrhea.



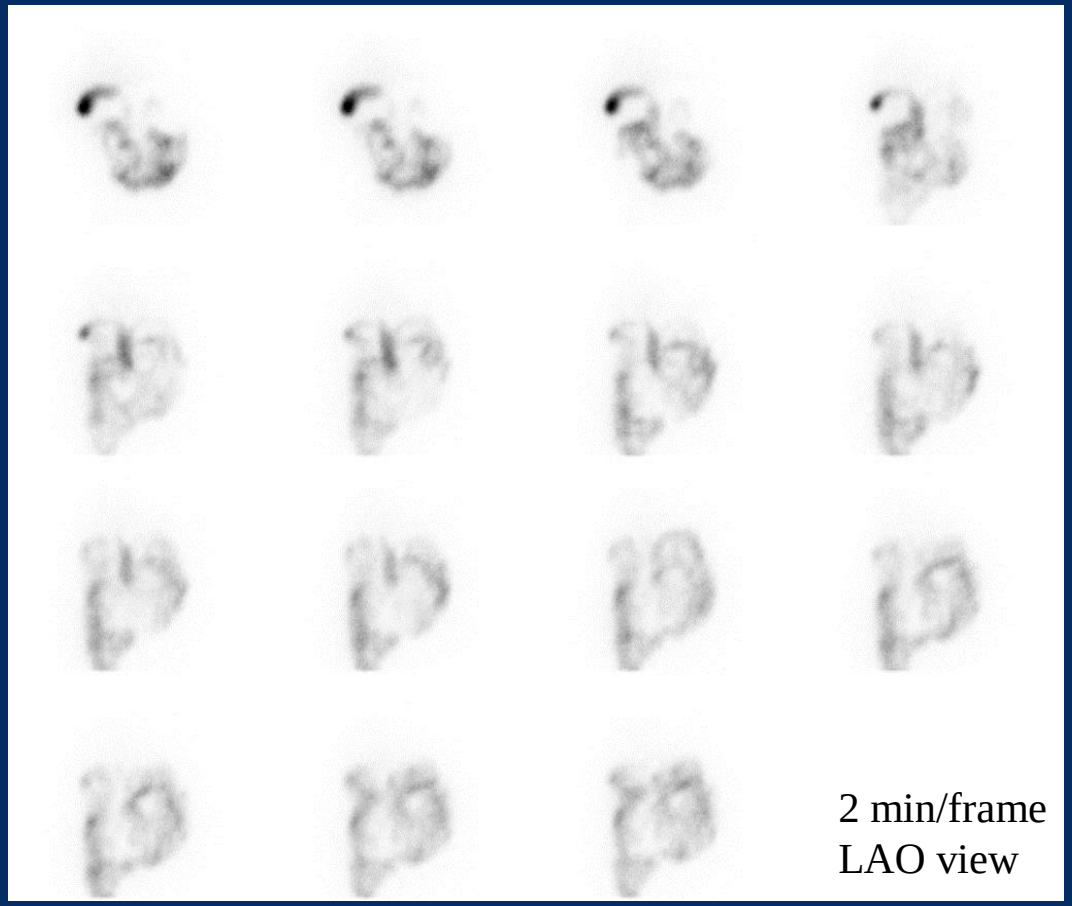
4 min/frame
Anterior view

Images courtesy of
Mark Tulchinsky, MD.

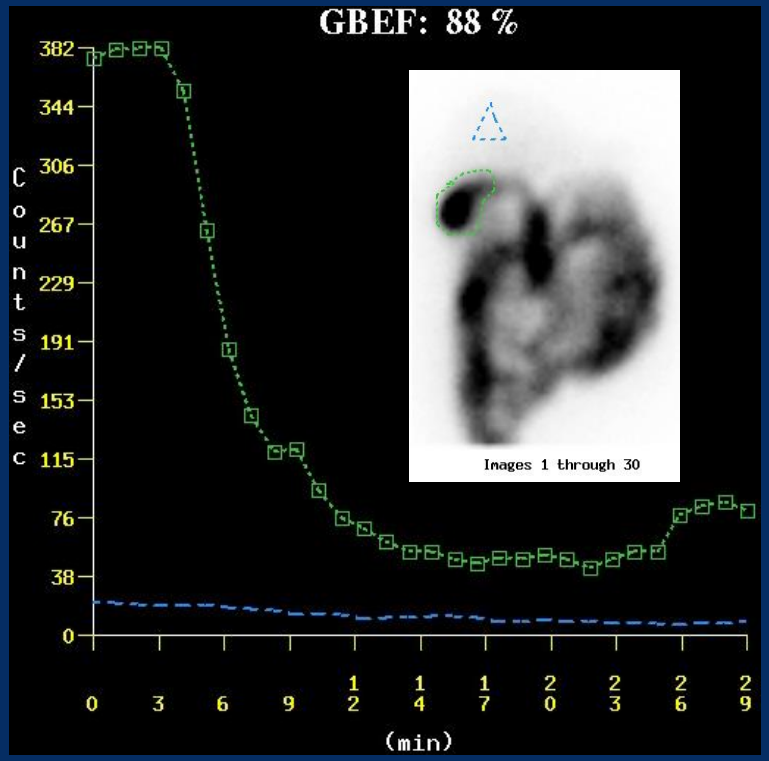
Gani JS. *Aust N Z J Surg.* 1998;68(7):514-519.
Hong SN, et al. *Dig Dis Sci.* 2004;49(5):820-827.

Case 2

Administering CCK in the Presence of Cholelithiasis – Safe and Informative



Gani JS. *Aust N Z J Surg.* 1998;68(7):514-519.
Hong SN, et al. *Dig Dis Sci.* 2004;49(5):820-827.



Impression: Normal study, biliary pain unlikely. Consider irritable bowel syndrome.

Images courtesy of Mark Tulchinsky, MD.

Case 2

EXAMINATION:
HEPATOBILIARY SCINTIGRAPHY

CLINICAL HISTORY:
The patient is referred for RUQ abdominal pain, considered to represent a type of biliary colic.

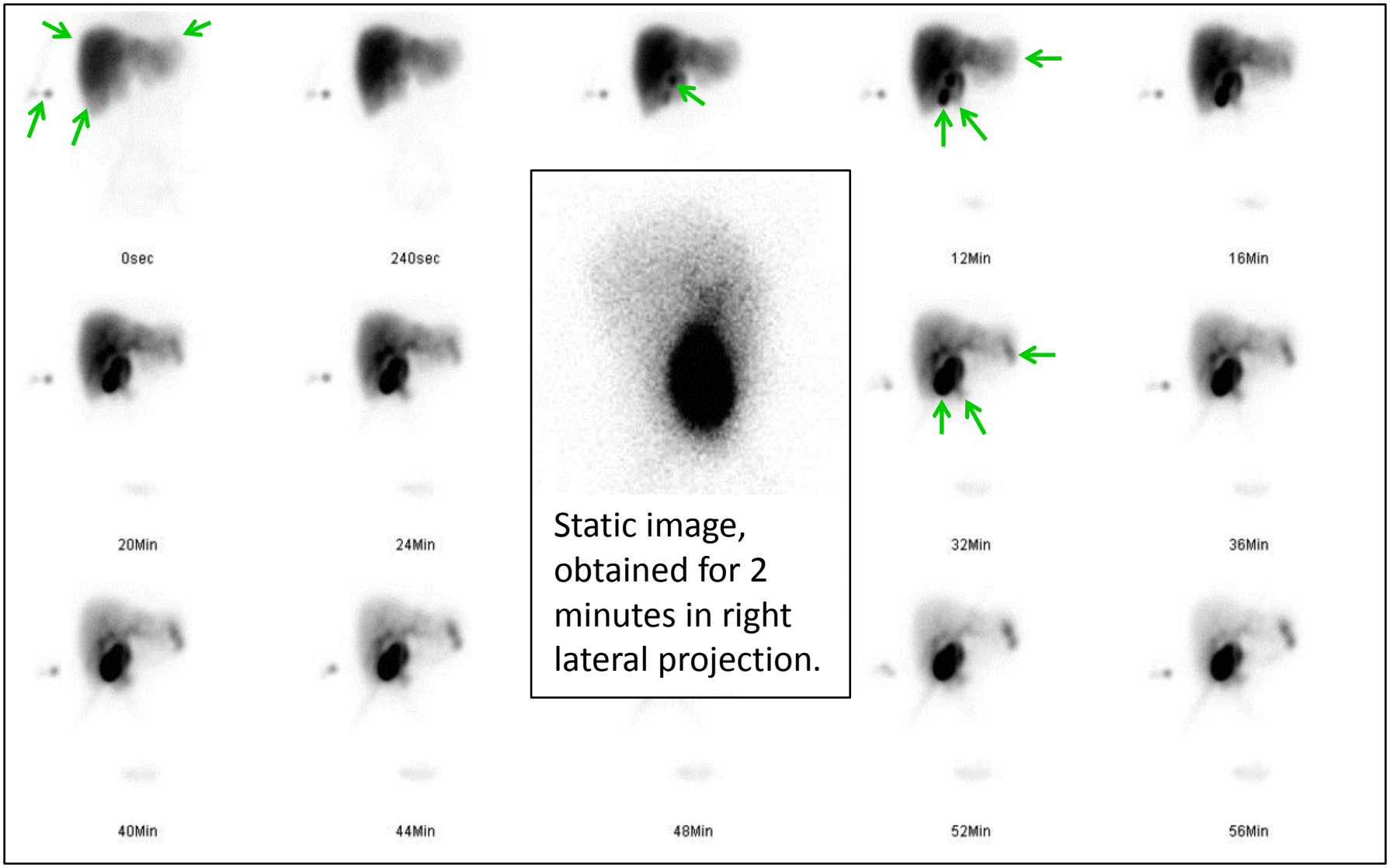
COMPARISON:
Ultrasound from 9/21/2017 (Normal findings).

TECHNIQUE:
After injection of the radiopharmaceutical, images were obtained in the anterior projection for one hour dynamically. After activity in the bowel and gallbladder were confirmed, synthetic cholecystokinin (sincalide 0.02 mcg/kg, infused over 30 min) was administered intravenously per protocol and additional images were obtained in LAO projection for 30 minutes. Because of the close anatomical positioning of the gallbladder with the C-loop of the duodenum, the patient was asked to drink water during sincalide stimulation in order to clear activity and prevent its overlap with the gallbladder. The gallbladder ejection fraction was calculated.

RADIOPHARMACEUTICAL:
Tc-99m-Mebrofenin 5.5 mCi IV, Use IV, 20171006080000, DF

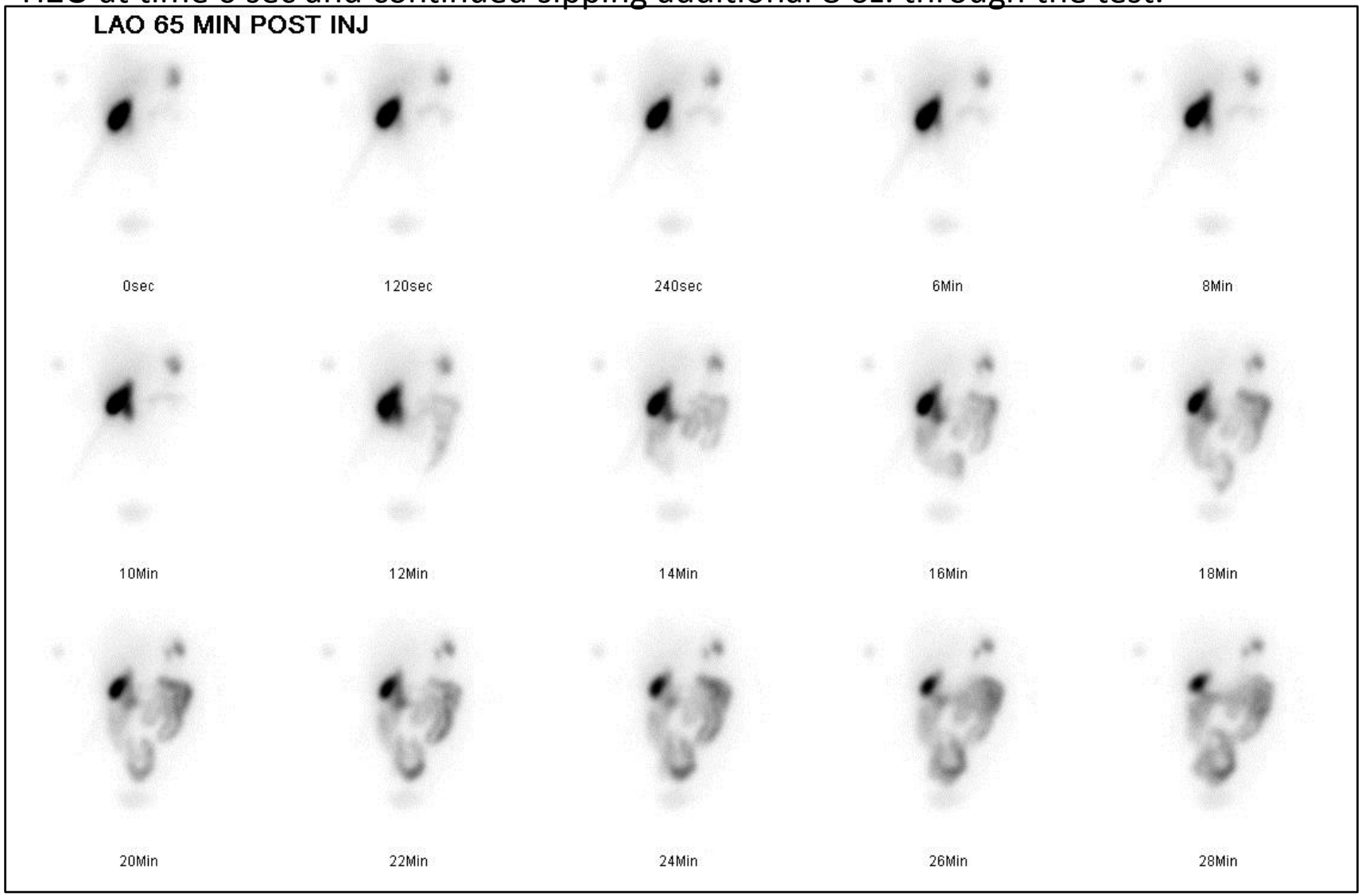
Case 3

First hour of dynamic imaging, obtained in anterior view at 15 seconds per frame, reformatted for display at 4 minutes per frame for visual inspection.



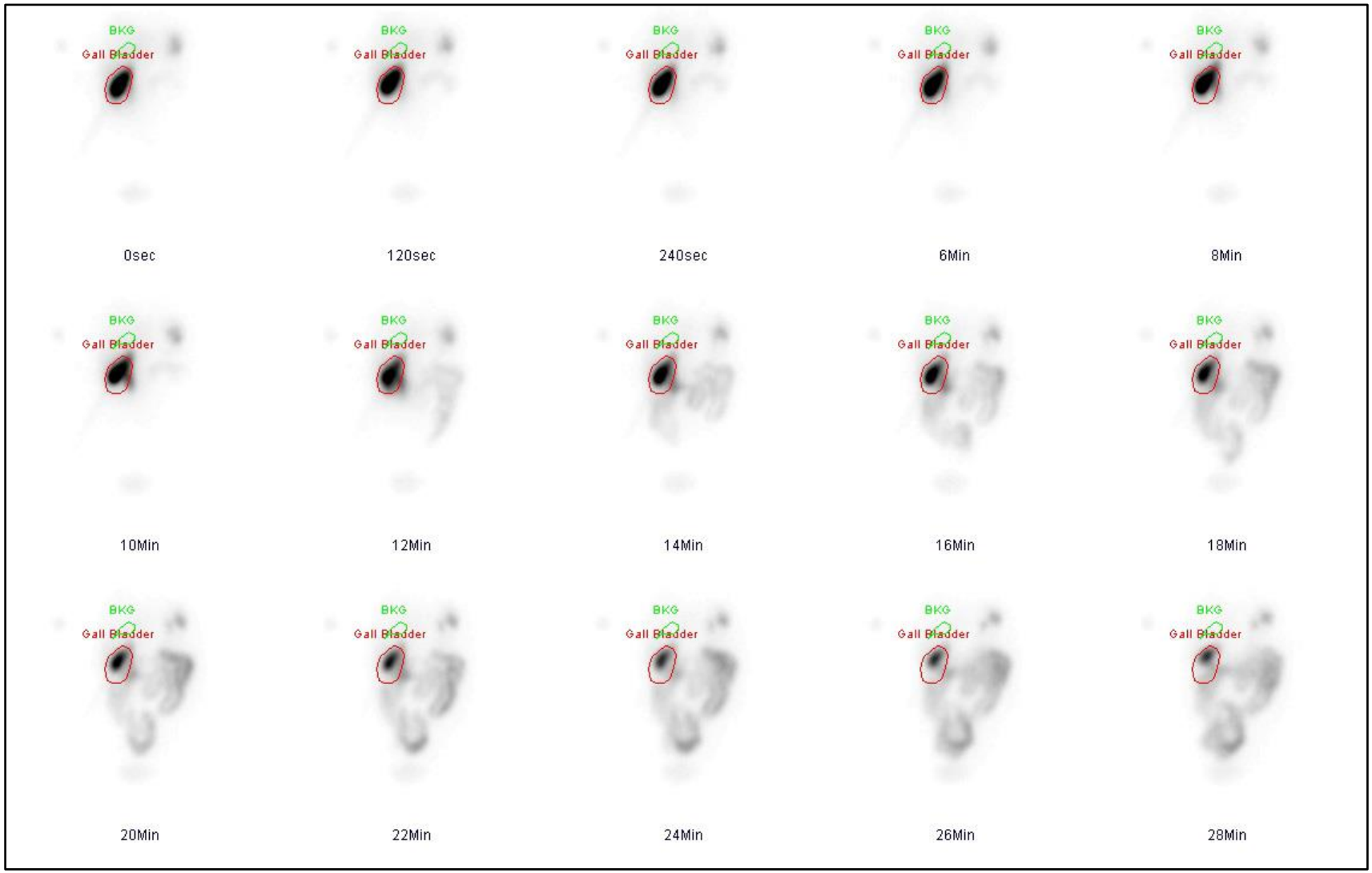
Case 3

Dynamic imaging, obtained during sincalide infusion, in the left anterior oblique view at 1 minute per frame, reformatted for display at 2 minutes per frame. Pt drank 8 oz. H2O at time 0 sec and continued sipping additional 8 oz. through the test.



Case 3

The same dynamic imaging, obtained during sincalide infusion, in the left anterior oblique view. In addition shown are regions of interest encompassing the gallbladder in red outline and background in green outline.

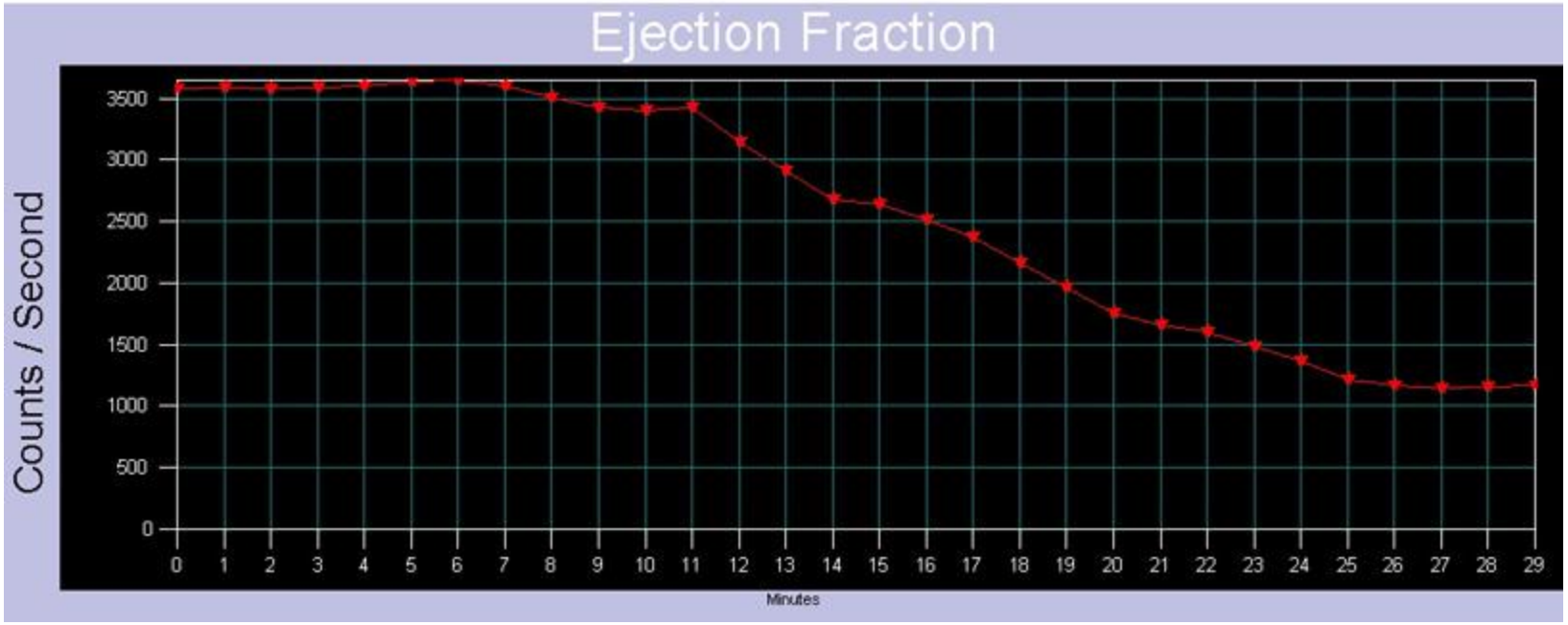


Case 3

The image depicts combination of all frames obtained during sincalide infusion, in the left anterior oblique view with regions of interest encompassing the gallbladder in red outline and background in green outline.

Max(min) 6.
Min(min) 27.
EF(%) 68.4

Calculation of ejection fraction (EF) is based on background corrected counts (activity). Normal EF is ≥ 35%



Case 3

FINDINGS:
There is normal hepatic extraction of radiotracer and excretion/clearance into the biliary system. The gallbladder fills normally. The activity transits into the C-loop of the duodenum, which is positioned very close to the gallbladder activity. Subsequently, there is rapid reflux into the stomach with significant activity localizing in the fundus at 16 minutes with some increase of the remainder of the first hour of imaging.

There is normal emptying of the gallbladder after administration of sincalide with a gallbladder ejection fraction of 68% (normal > 35%). The small bowel activity is in normal anatomical pattern. The patient has further reflux into the stomach in spite of drinking water during this examination. The patient also reported significant abdominal pain during sincalide infusion.

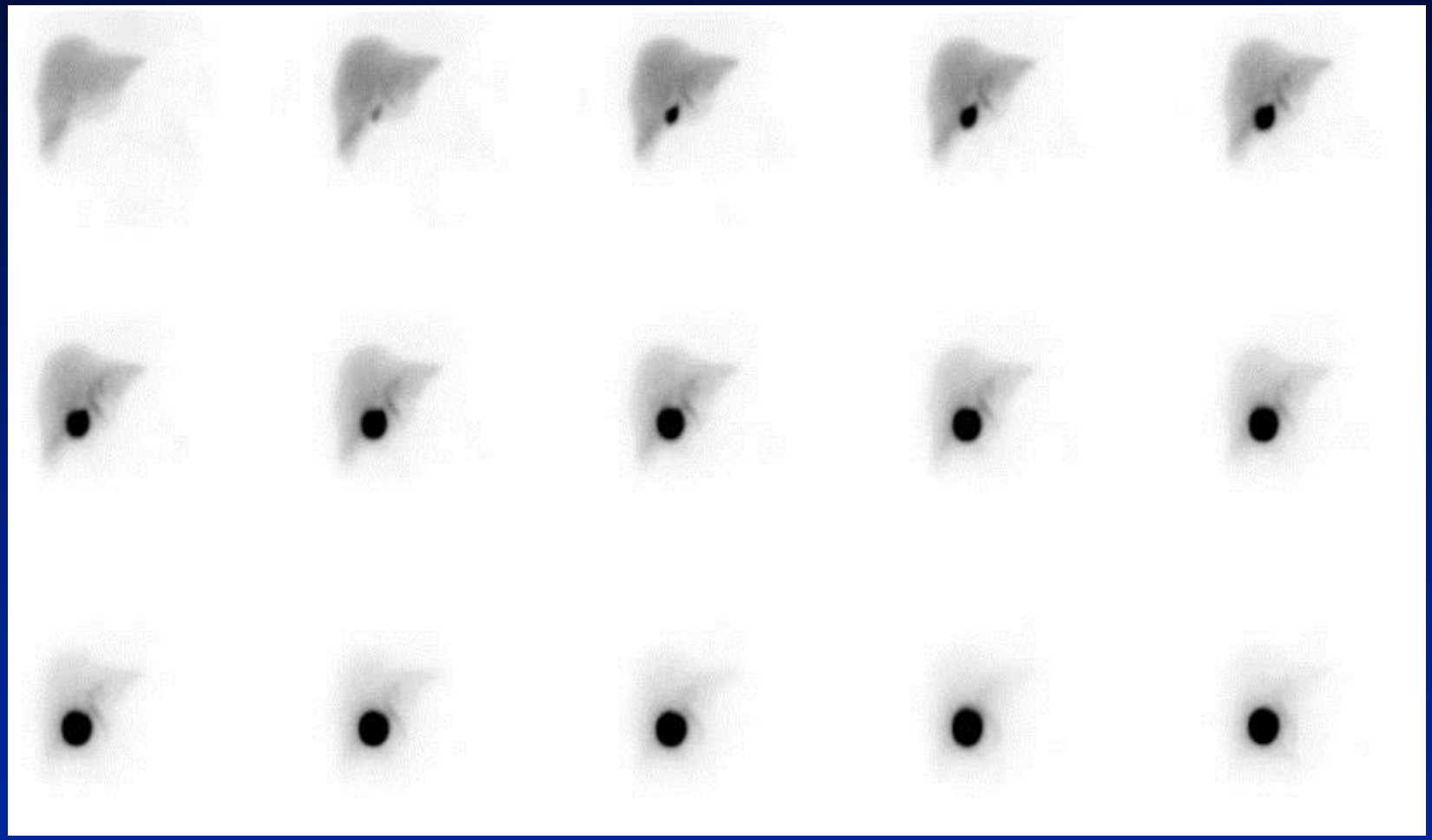
The patient was interviewed following the study revealed that the pain is most acute in the right upper abdominal quadrant. She has been troubled by these abdominal pains for the past several weeks. She has also suffered from acute episodes of chest pain for which she has been seen in the emergency room. Her abdomen during the several weeks has been also tender to palpation.

Case 3

IMPRESSION:

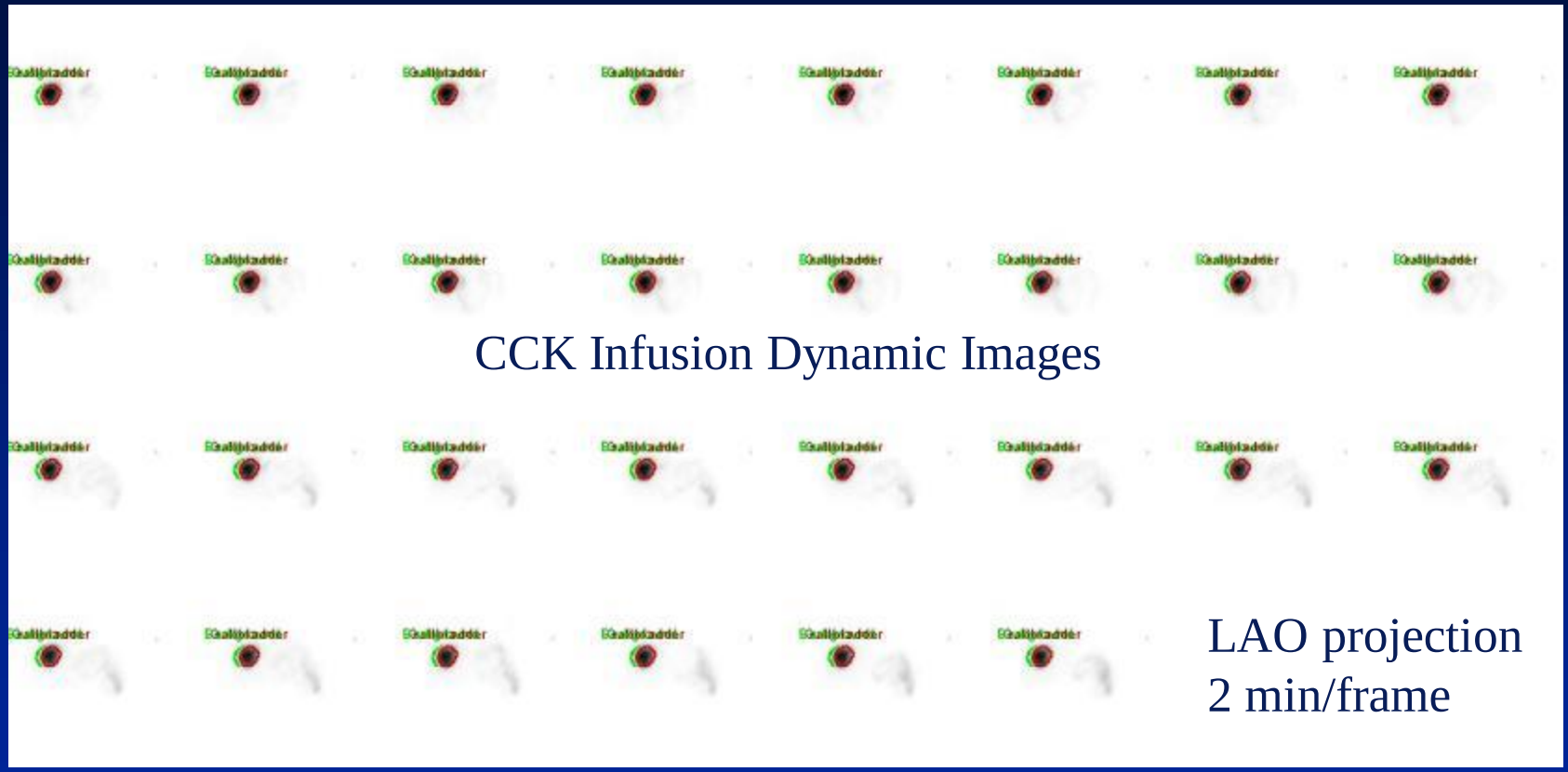
1. Normal gallbladder filling and ejection fraction following sincalide stimulation of 68%.
2. There is prominent bile reflux into the stomach, consider bilious gastritis.
3. Given the patient's complaints of episodic chest pain associated with abdominal pain, gastroesophageal reflux with bilious contents should be considered. The patient did not have chest pain during this examination nor did the images show gastroesophageal reflux.

If there is early and preferential GB filling, does that predict normal GB function & obviates need for challenge? No!



ANT projection
4 min/frame

Case 4



CCK Infusion Dynamic Images

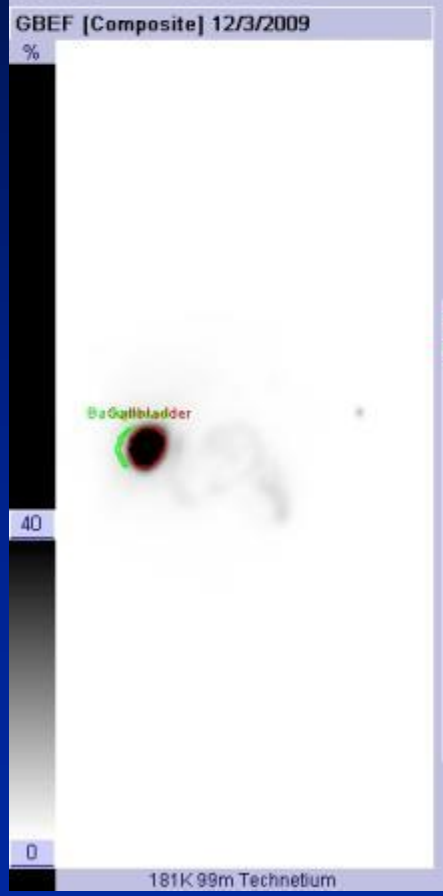
LAO projection
2 min/frame

Case 4

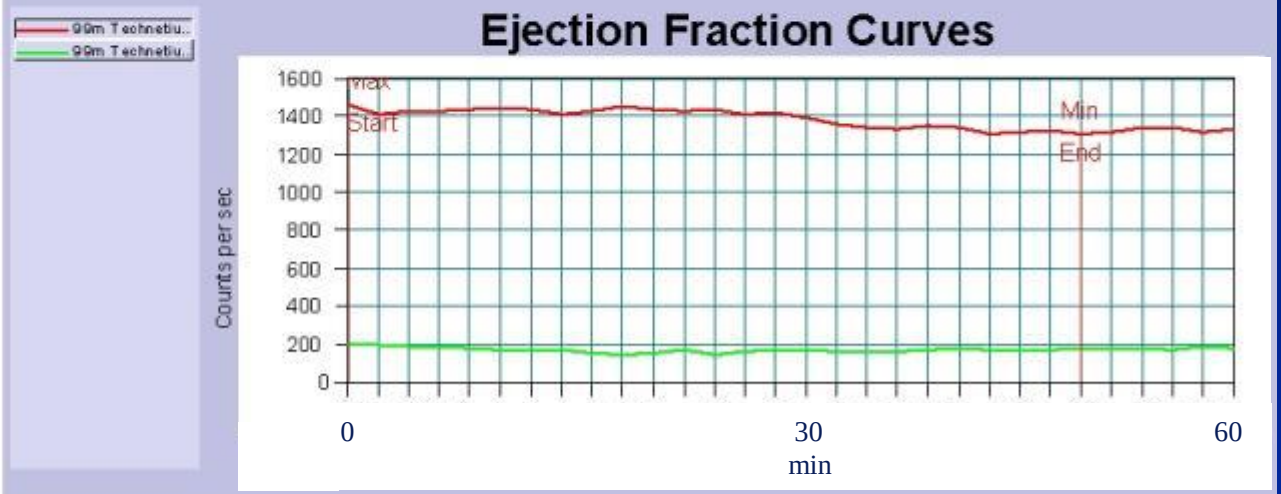
Bkgd Correction	On
Decay Correction	On

Parameter	99m Technetium
Ejection Fraction	10 %
EF interval begin	0 mins
EF interval end	24 mins
T Max	0 mins
T Min	24 mins

Now, what's the diagnosis?



Series Description: GBEF
Series Date: 12/3/2009
Series Time: 9:12:58 AM
Radiopharmaceutical 1: 185.0 MBq (5.00 mCi) Mebrofenin
Energy Window Group 1: 99m Technetium



Case 4

Chronic GB/Biliary Diseases: Spectrum of Conditions

Acalculous

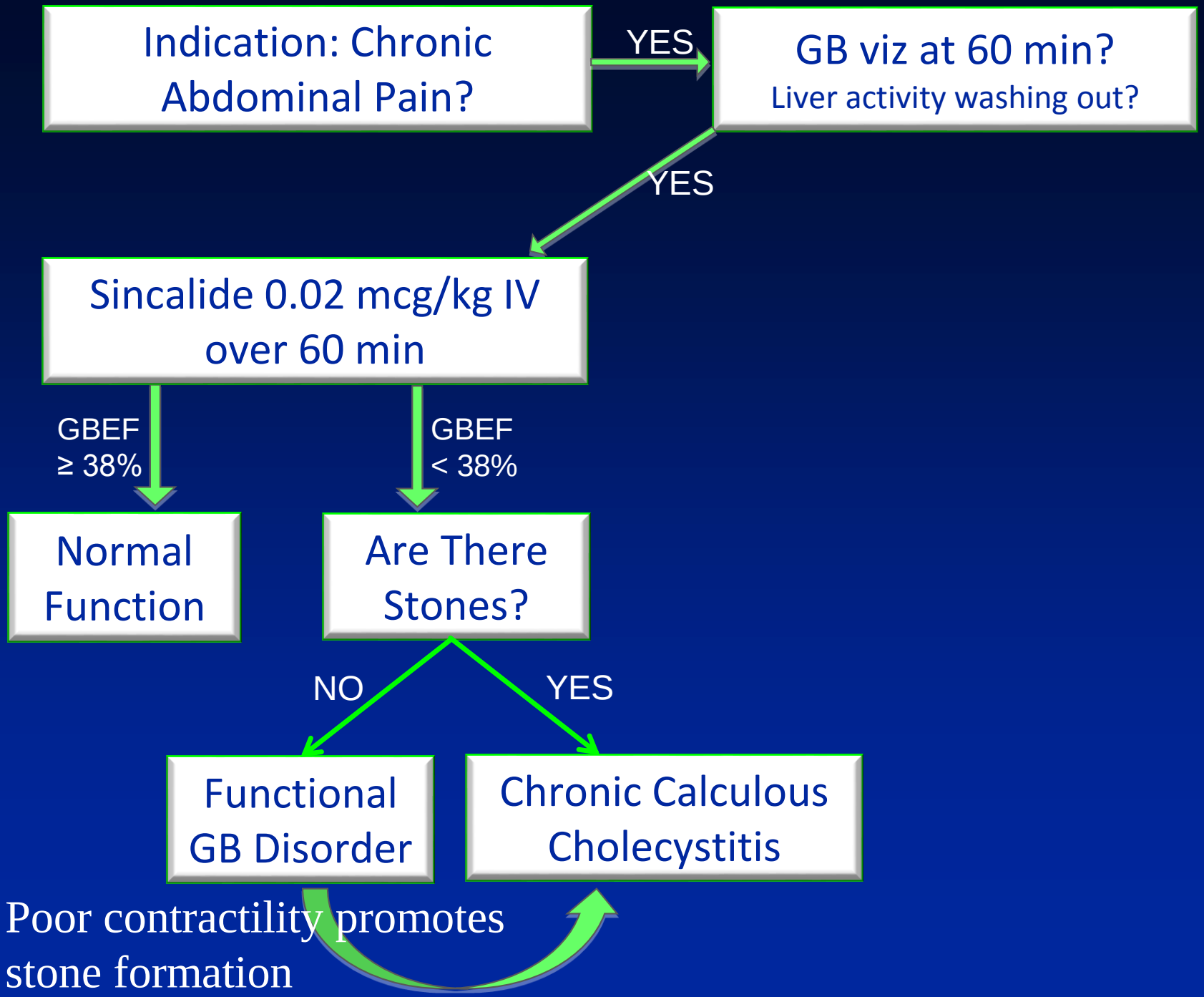
- Functional GB disorder[1]
  - "Biliary dyskinesia"
  - "Gallbladder dyskinesia" (surgeons' label)
  - "Chronic acalculous cholecystitis" or "acalculous cholecystopathy"
  - "Chronic acalculous biliary disease"
  - "Acalculous biliary disease"
  - "Cystic duct syndrome"
  - "GB spasm"

Calculous

- Chronic calculous cholecystitis

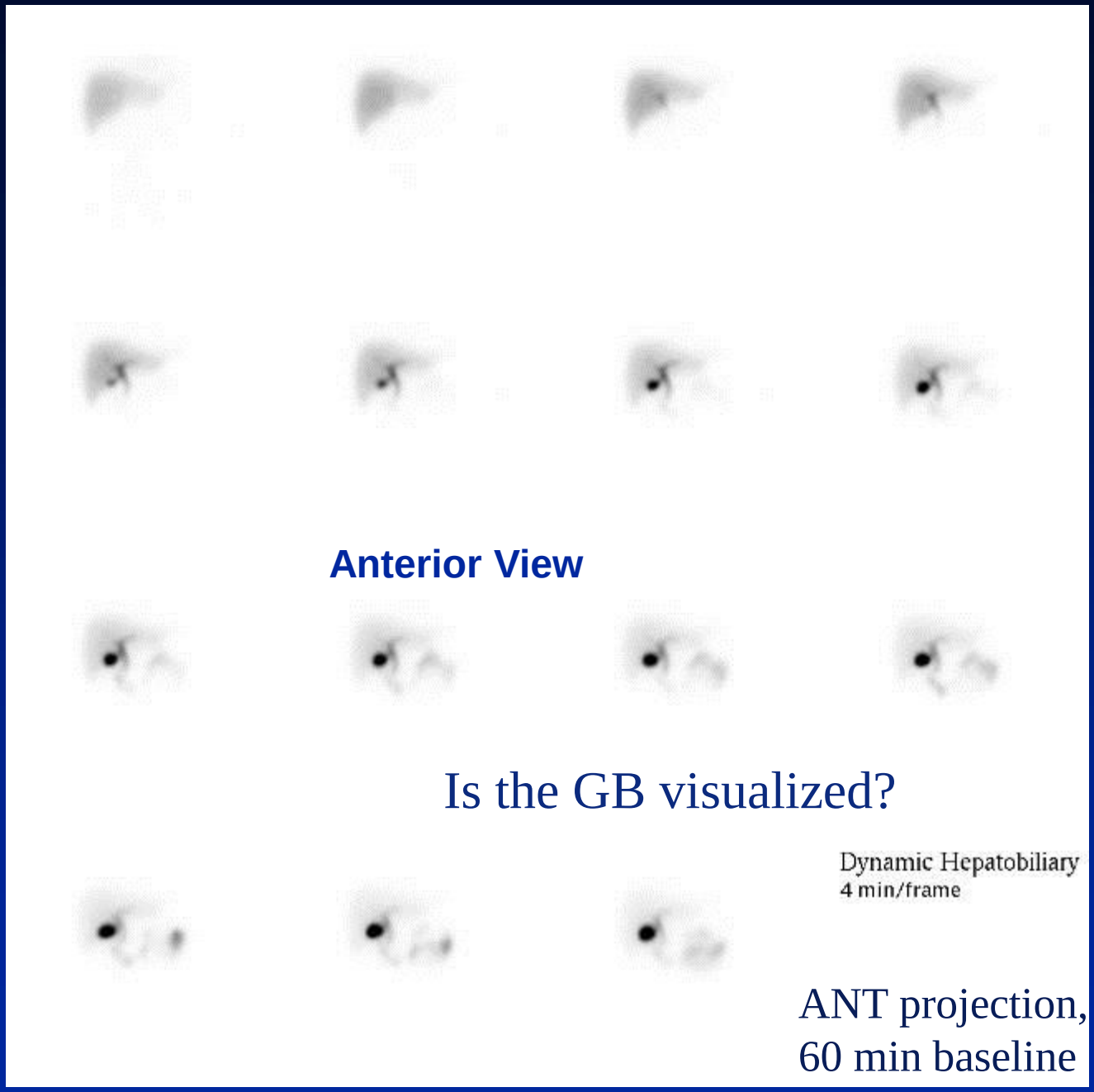
- Sphincter of Oddi dysfunction
  - "Biliary dyskinesia" (gastroenterologists' label)

1. Peter B. Cotton, et. al. Gallbladder and Sphincter of Oddi Disorders. [Rome III and IV Classification.] Gastroenterology (Volume 150, Issue 6, May, 2016)


Indication: Chronic Abdominal Pain?
YES
GB viz at 60 min?
Liver activity washing out?
YES
Sincalide 0.02 mcg/kg IV over 60 min
GBEF ≥ 38%
GBEF < 38%
Normal Function
Are There Stones?
NO
YES
Functional GB Disorder
Chronic Calculous Cholecystitis
Poor contractility promotes stone formation

Case 5

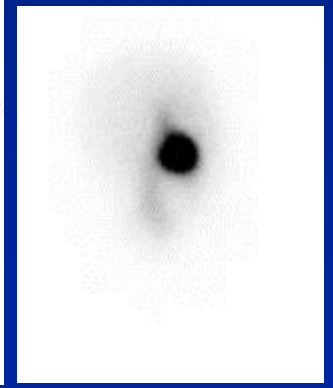
- 35 y/o female with chronic abdominal pain, RUQ, characterized as biliary colic
- Referred for sincalide cholescintigraphy
- Ultrasound of the abdomen is normal
- You are brought this study to check



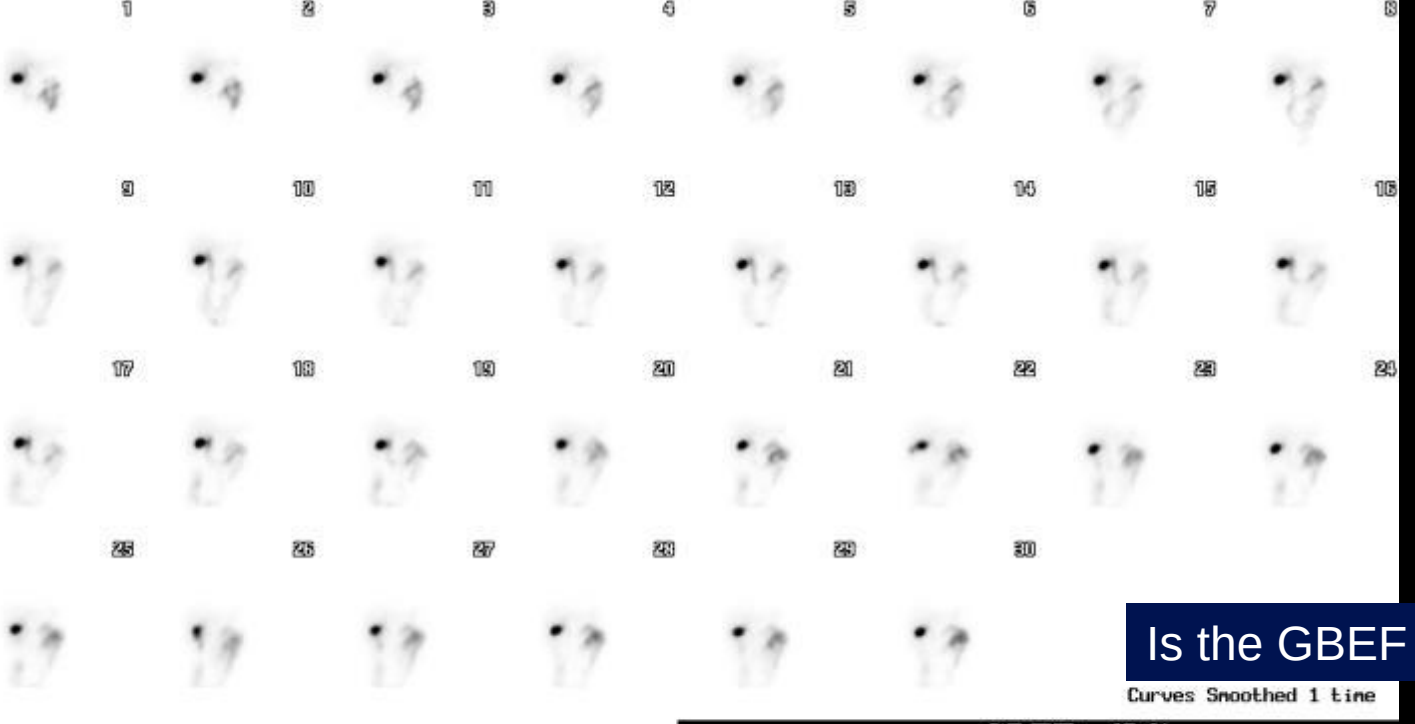
Is the GB visualized?

ANT projection,
60 min baseline

Rt. Lat.
@60 min

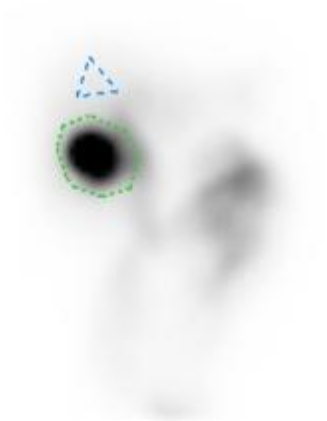


Case 5

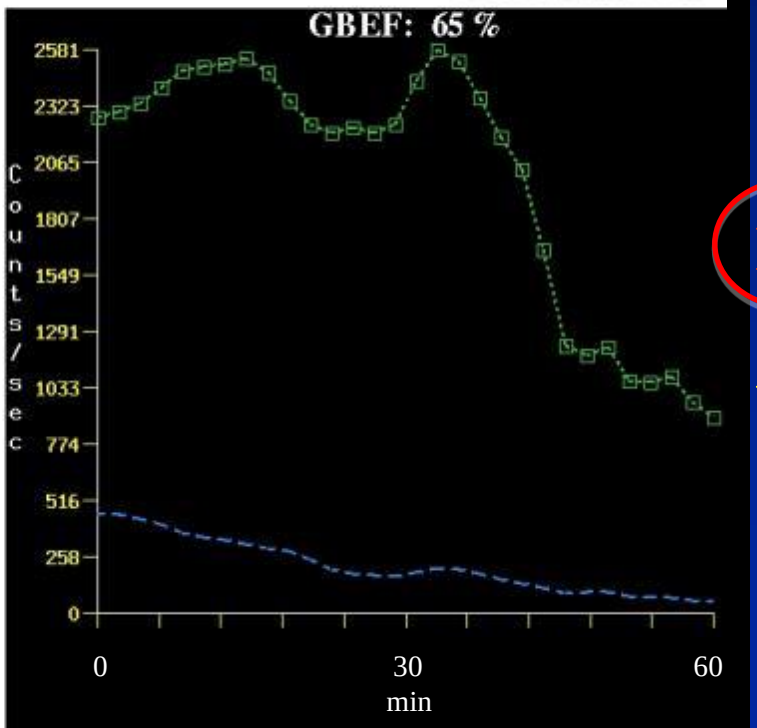


Is the GBEF normal?

CCK Infusion Images



Images 1 through 16



Yes

No

Unsure

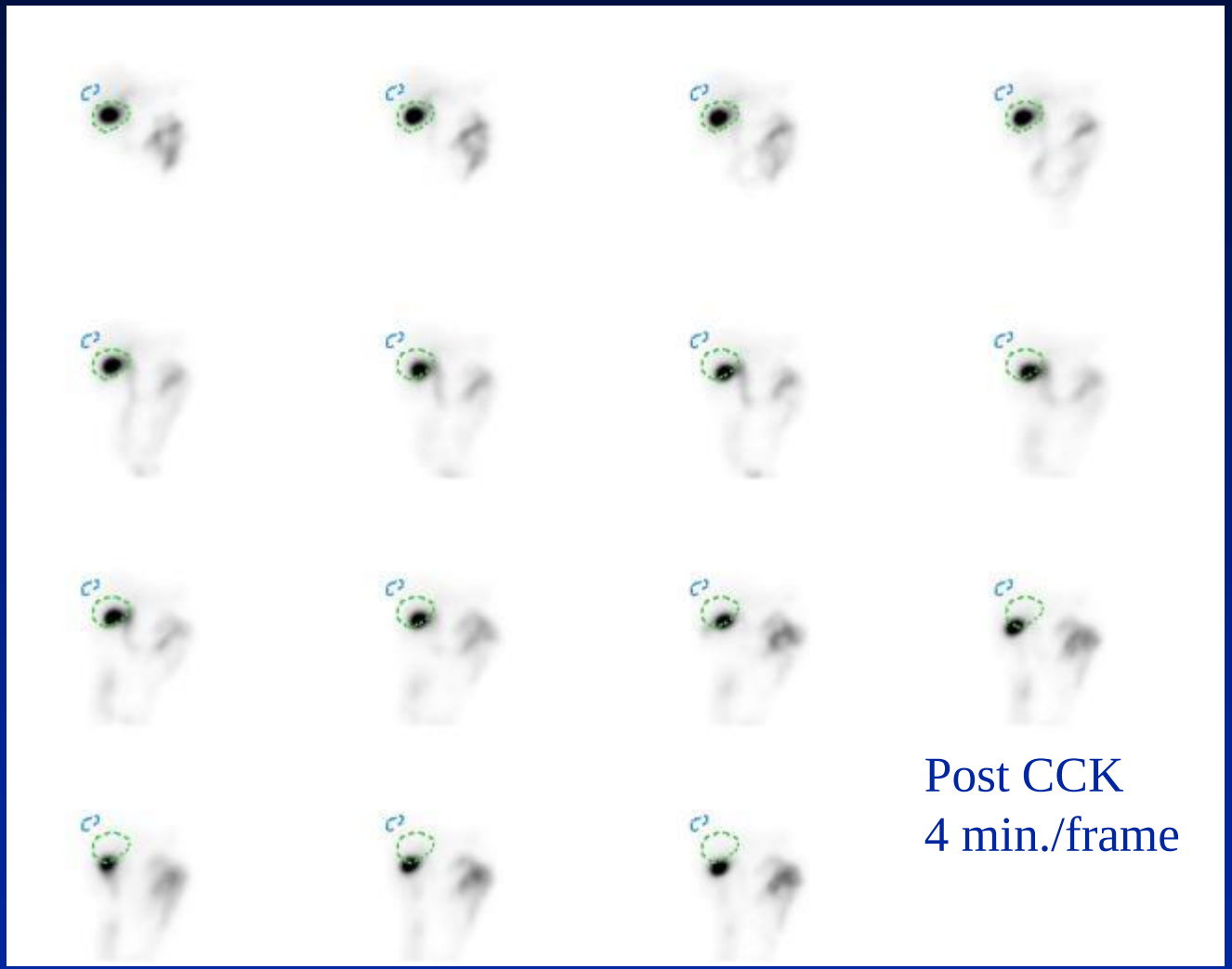
Case 5


What else do you need to make the final call?
CCK Infusion Dynamic Images
4 min/frame

Case 5

Case 5

Take-Home Message: Look at the QA Image for motion!



Post CCK
4 min./frame

Case 5

Cholecystokinin-cholescintigraphy in adults: Consensus recommendations of an interdisciplinary panel.

DiBaise JK, Richmond BK, Ziessman HH, Everson GT, Fanelli RD, Maurer A, Ouyang A, Shamamian P, **Simons RJ**, Wall LA, **Weida TJ**, Tulchinsky M.

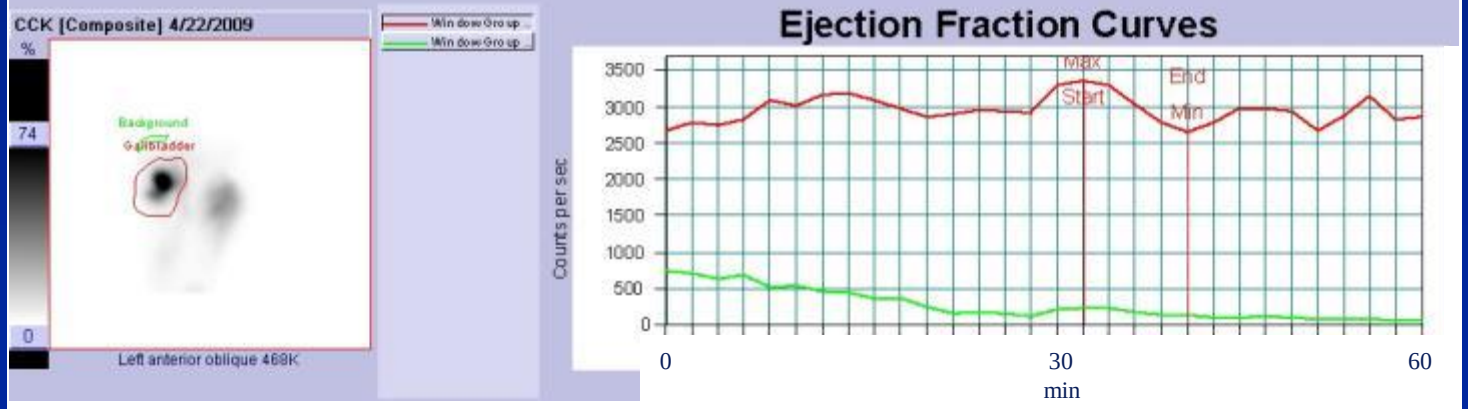
Clin Gastroenterol Hepatol. 2011 May;9(5):376-84.
doi: 10.1016/j.cgh.2011.02.013

		Parameter	Window Group 1
Bkgd Correction	On	Ejection Fraction	21 %
Decay Correction	On	EF interval begin	16 mins
		EF interval end	20 mins
		T Max	16 mins
		T Min	20 mins

Impression: Abnormal GBEF of 21%, consistent with diagnosis of functional gallbladder disorder in the proper clinical setting.

Series Description: CCK
Series Time: 10:34:56 AM
Energy Window Group 1:

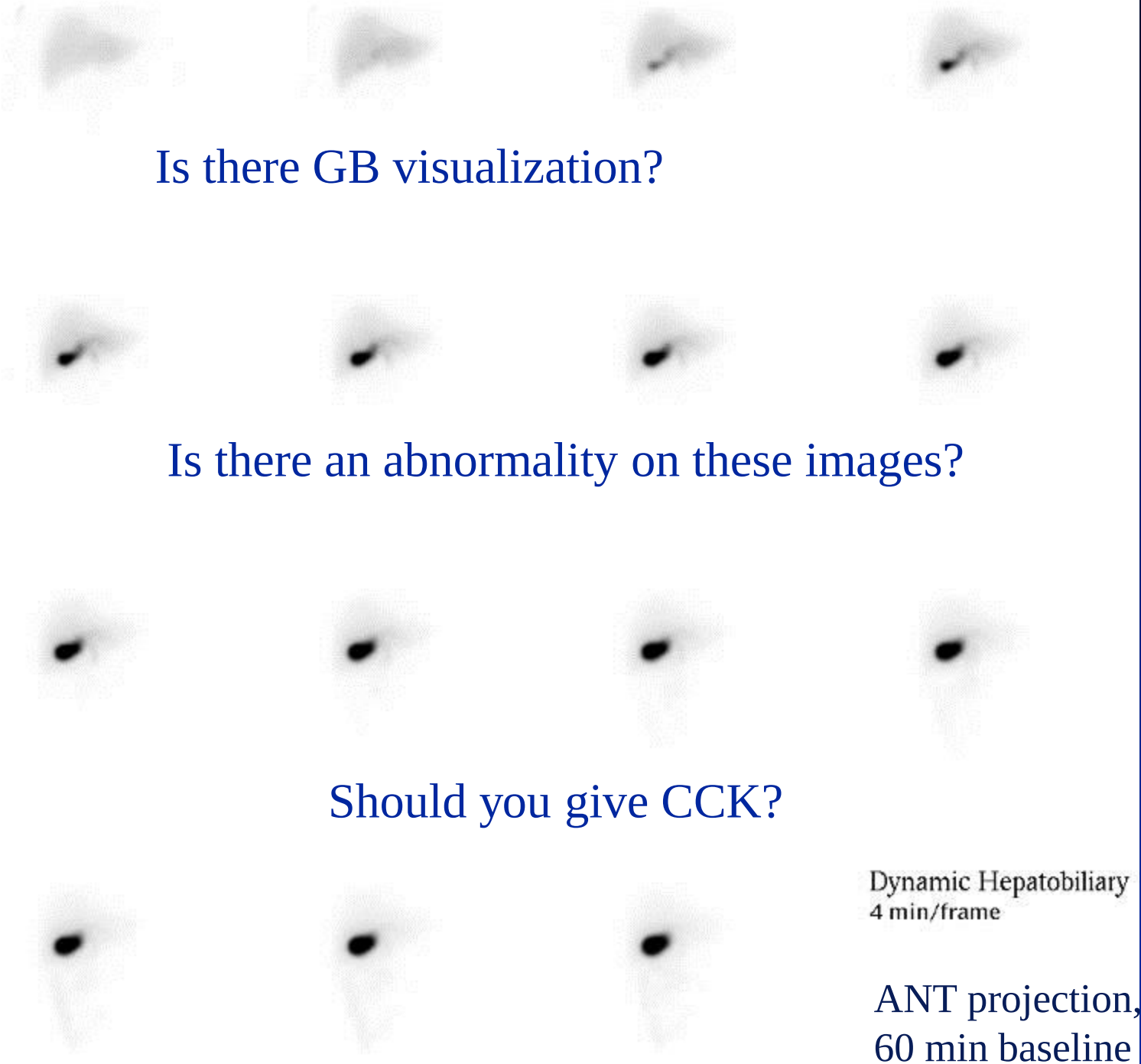
Series Date: 2/20/2009
Radiopharmaceutical 1: 0.0 MBq (0.00 mCi)



Case 5

Case 6
Chronic Abdominal Pains

- 32 y/o female with abdominal pain after meals, she remembers such symptoms for most of her life, recently worsened
- Request: “Evaluate for gallbladder dyskinesia”



Is there GB visualization?

Yes
No
Unsure

Is there an abnormality on these images?

Yes
No
Unsure

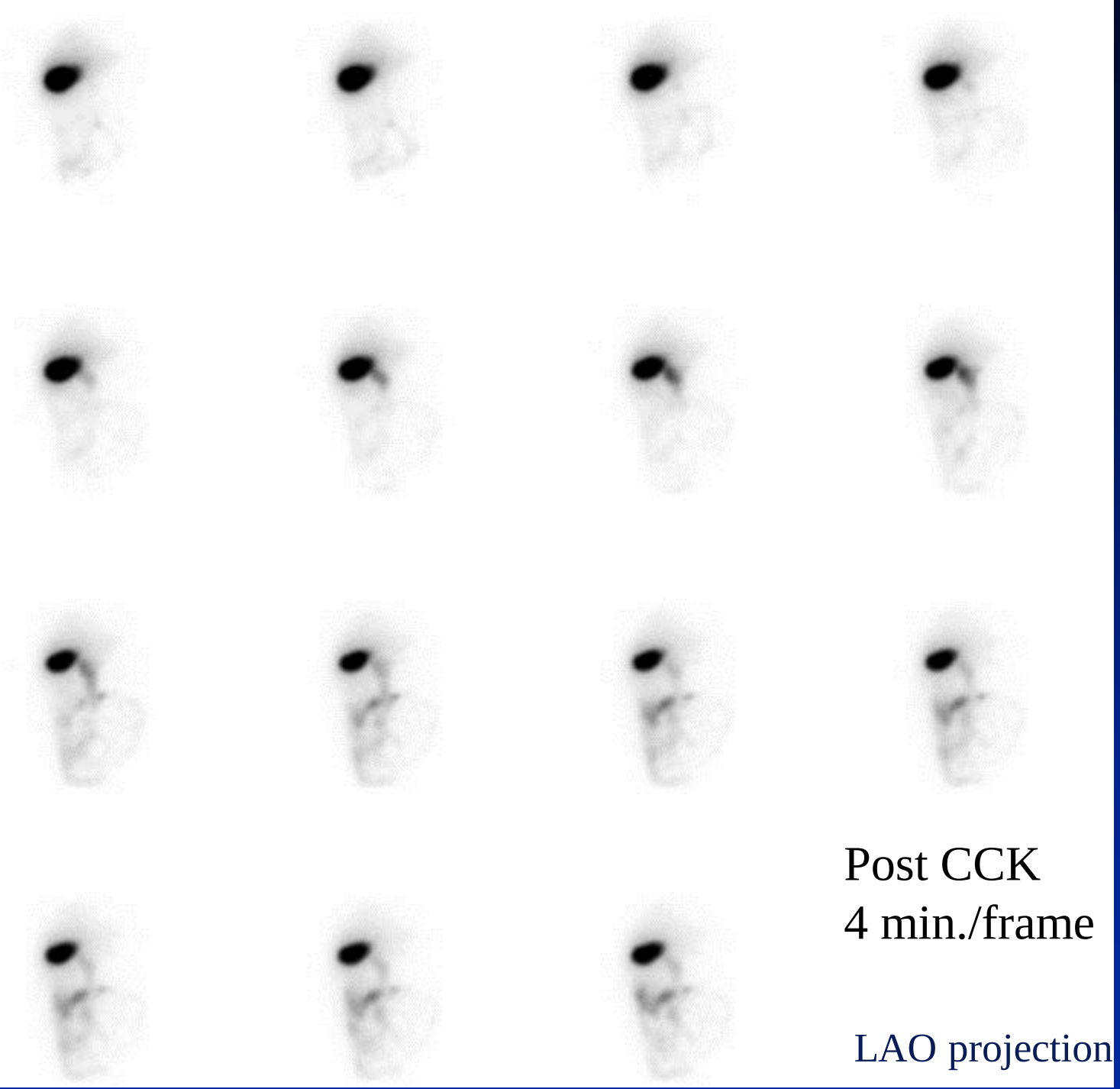
Should you give CCK?

Yes
No
Unsure

Dynamic Hepatobiliary
4 min/frame

ANT projection,
60 min baseline

Case 6

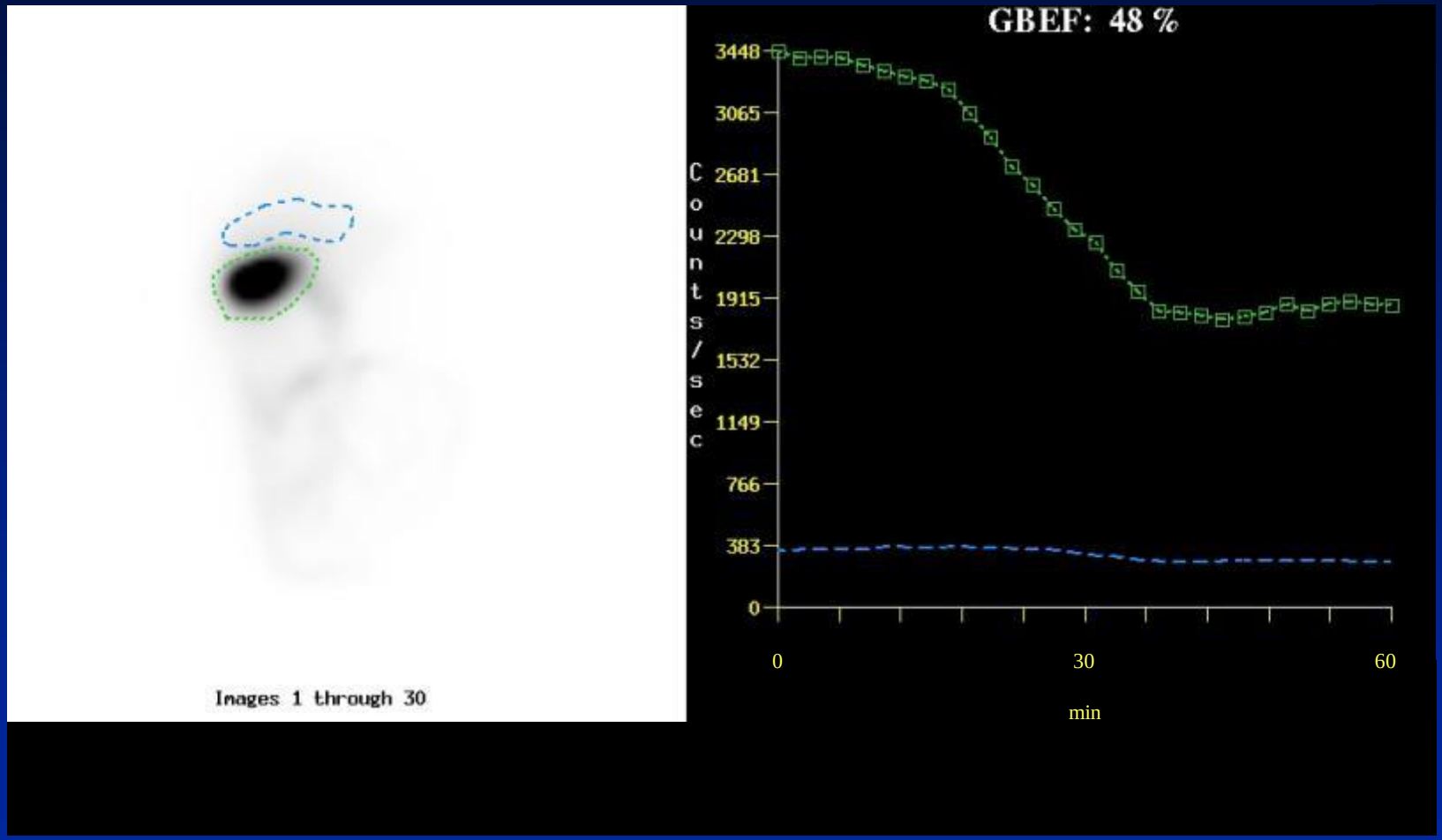


Post CCK
4 min./frame

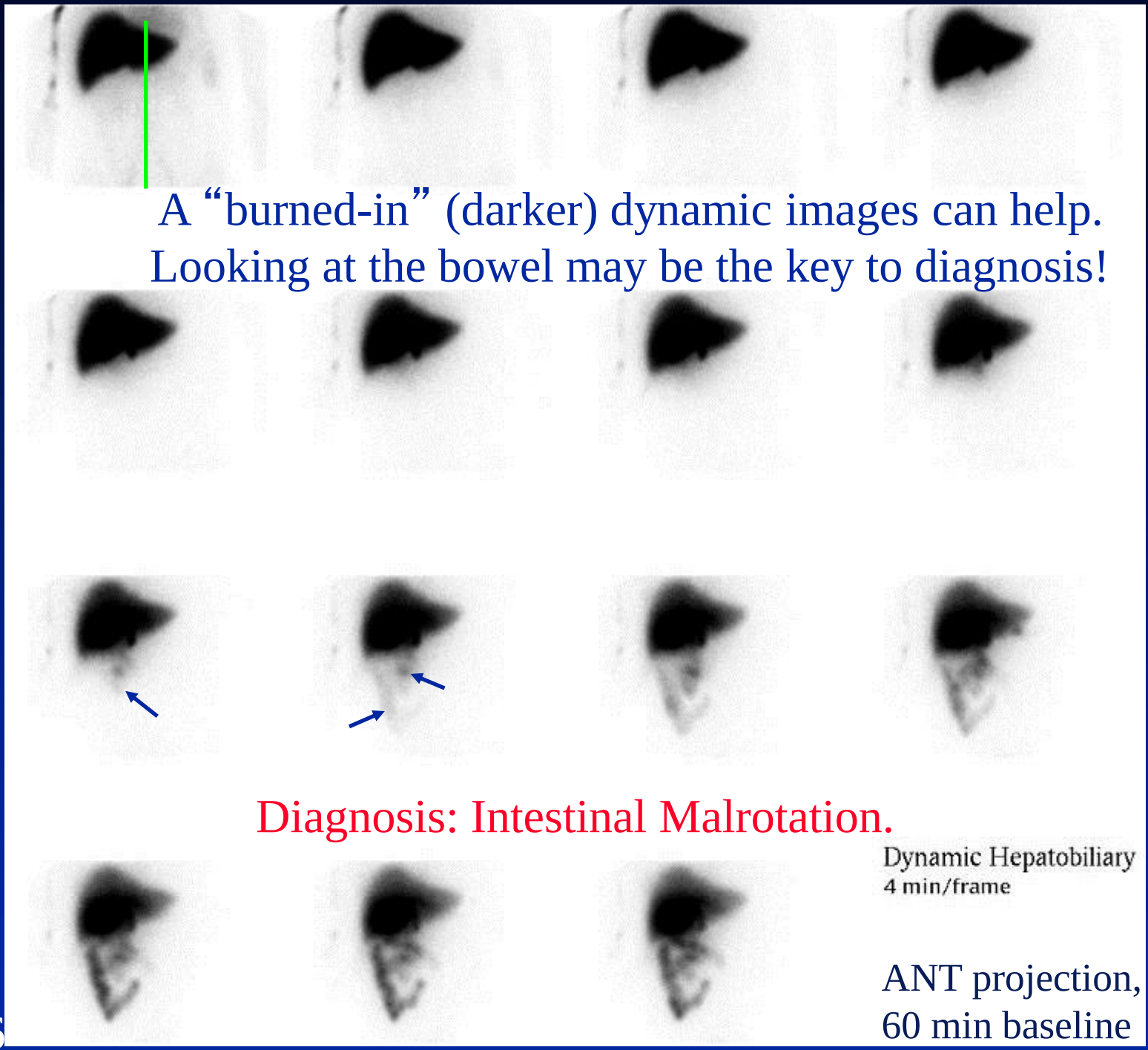
LAO projection

Case 6

What is your final reading? Normal Study. Abnormal Study.



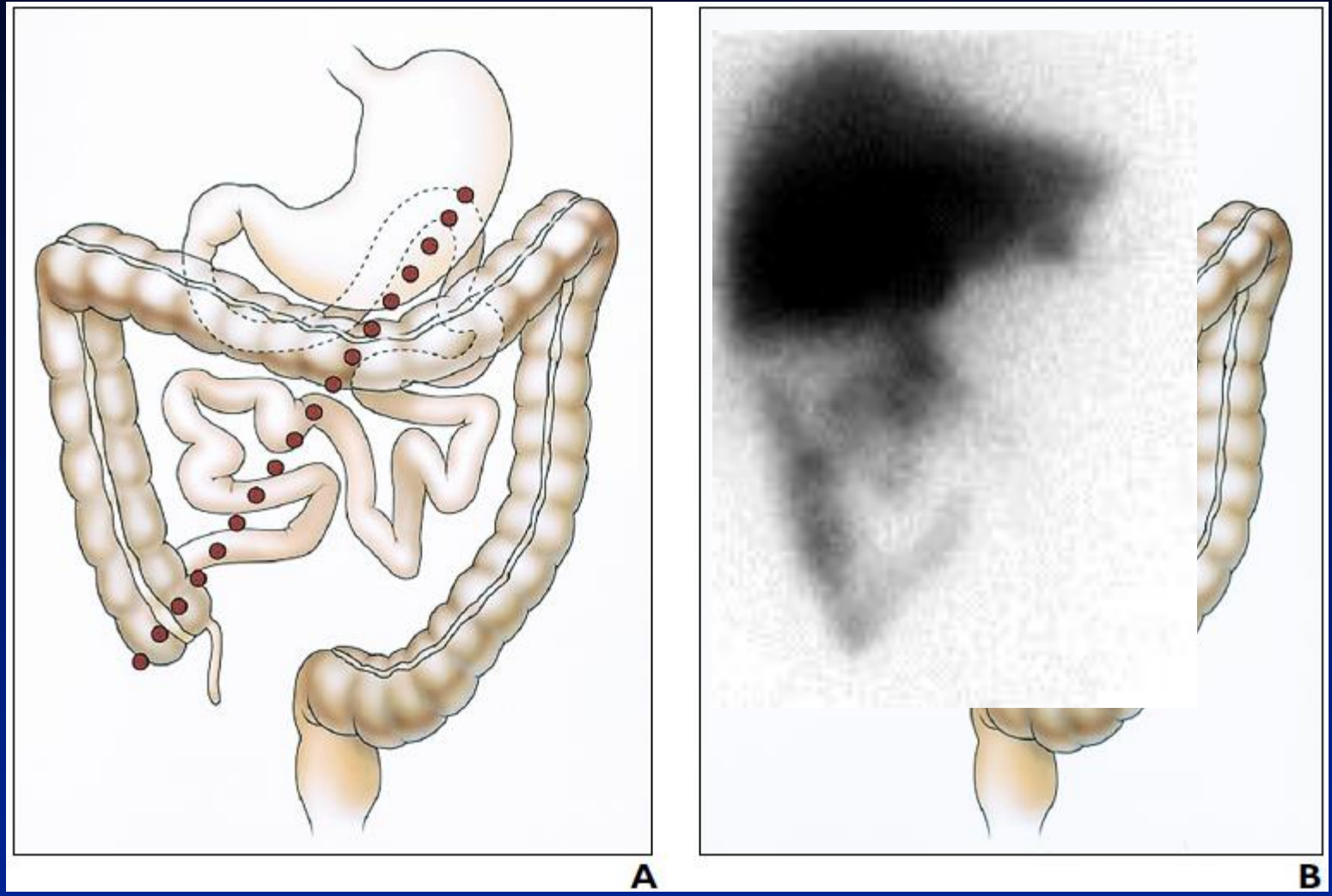
Case 6


A “burned-in” (darker) dynamic images can help.
Looking at the bowel may be the key to diagnosis!
Diagnosis: Intestinal Malrotation.
Dynamic Hepatobiliary
4 min/frame
ANT projection,
60 min baseline

Case 6

Diagnosis – Intestinal Malrotation

- Key finding – tracer outlined duodenum (and proximal small bowel) do not cross the midline
- Take-home message – provide and look at adequately scaled images to visualize proximal small intestine
- Follow up recommendation – upper gastrointestinal barium series
- Treatment – Laparoscopic Ladd procedure
- Failure to diagnose – continuing abdominal pain, valvulus, intestinal obstruction and internal hernia



A. Drawing shows that normal 270˚ rotation and fixation of midgut results in familiar positioning of bowel with broad mesenteric attachment (dotted line).
B. Drawing shows that malrotation results in malpositioned bowel and narrow base of mesenteric fixation (dotted line), which is prone to midgut volvulus. Abnormal fibrous peritoneal bands of Ladd (curved lines) that attach to right colon predispose to internal hernia in older patients.

Case 6

Final Note – The Surgical Report

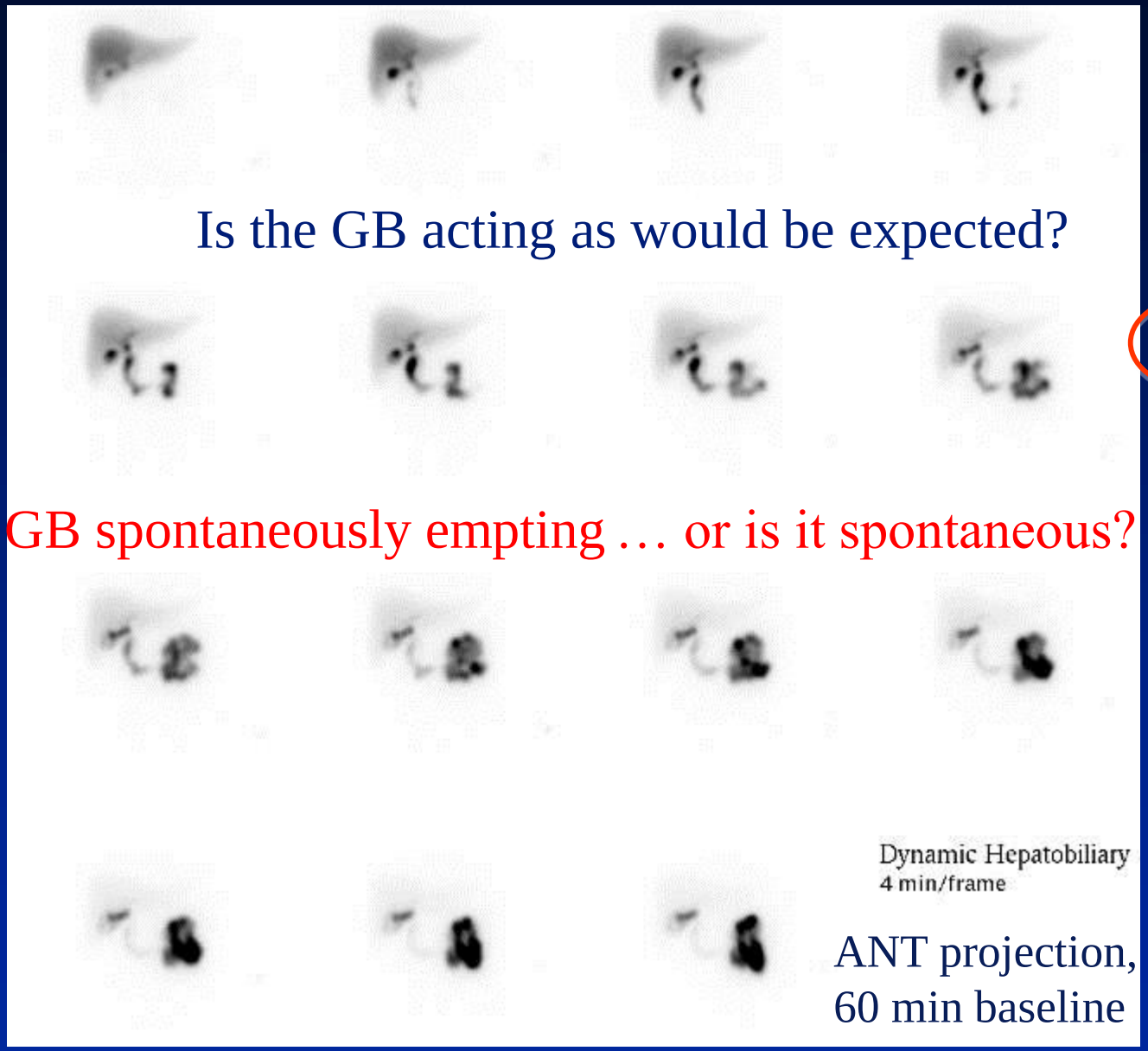
Cecum was identified in the left upper quadrant and the lateral peritoneal attachments (Ladd bands) were taken down using the harmonic scalpel. This allowed the cecum to become mobile medially. At the posterior aspect of the cecum there were Ladd bands attaching it to the duodenum, and these were taken down using a combination of blunt and sharp dissection. The cecum continued to be rotated toward the midline, and this freed up and exposed the duodenum posteriorly. There were adhesions of the duodenum in the retroperitoneum, and these were taken down using a combination of blunt and sharp dissection until it was freed.

With the duodenum mobilized, we performed an appendectomy.

We then turned our attention to placing the bowel in the appropriate quadrants. The cecum easily reached the right upper quadrant. We chose not to tack it into position. The small bowel was appropriately positioned in the left lower quadrant.

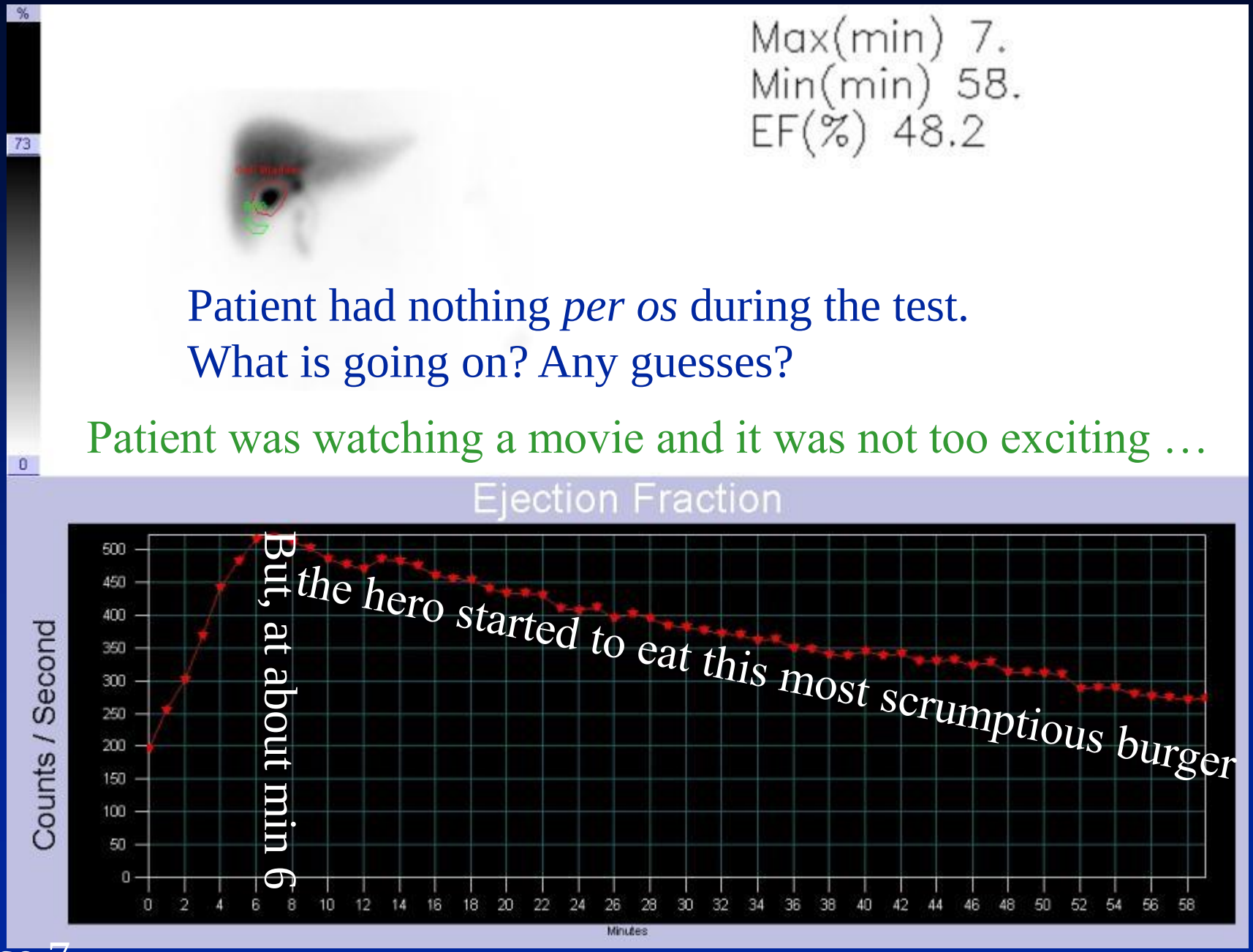
Case 7

- Chronic Abdominal Pain
- Is the GB normal vs. abnormal (responsible for patient's pains)?


Is the GB acting as would be expected?
Yes!
No!
GB spontaneously empting … or is it spontaneous?
Dynamic Hepatobiliary
4 min/frame
ANT projection,
60 min baseline

Case 7

ANT projection, 60 min baseline scintigraphy, activity of the GB showed:



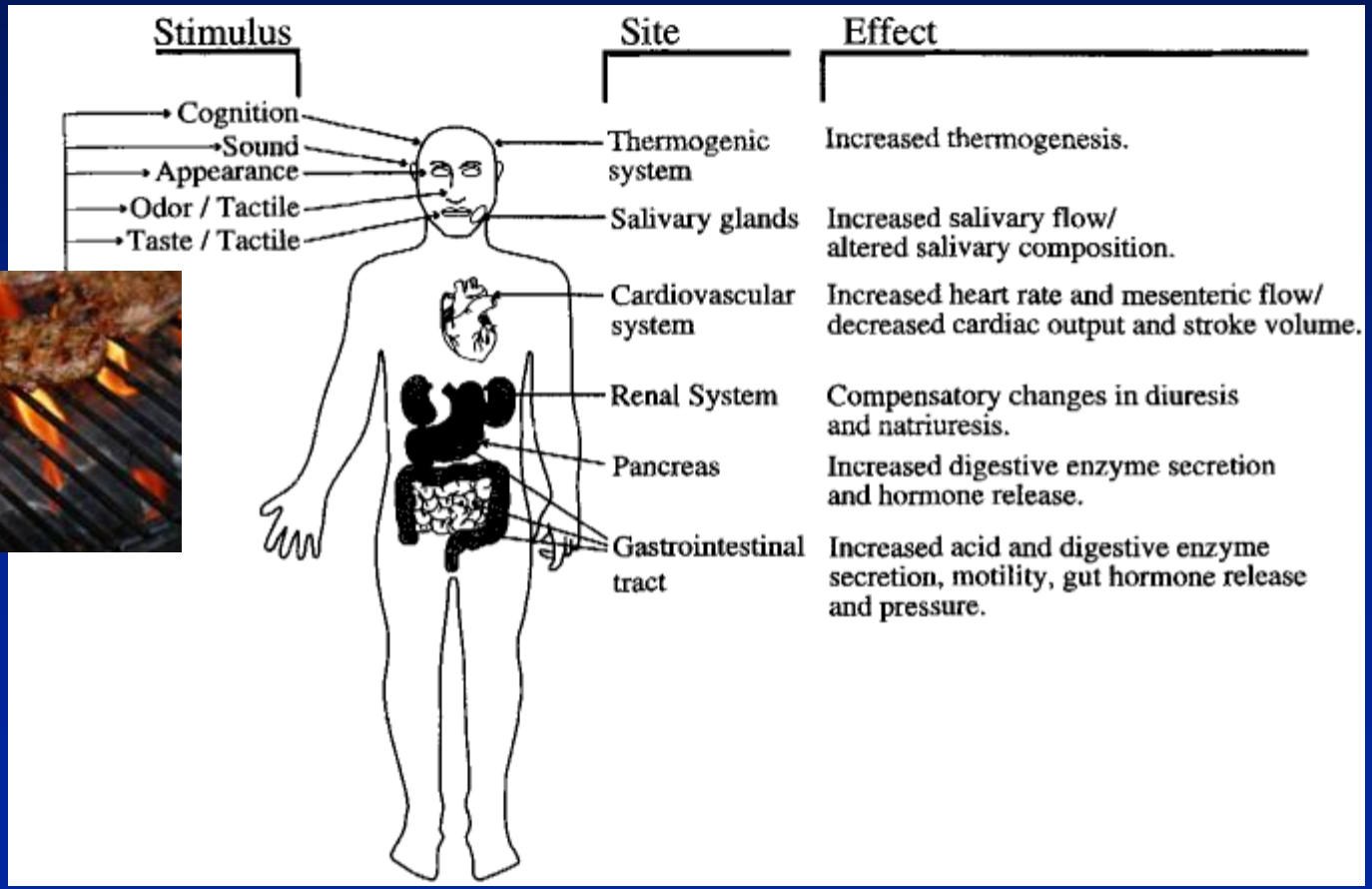
Patient had nothing *per os* during the test.
What is going on? Any guesses?

Patient was watching a movie and it was not too exciting …

Case 7

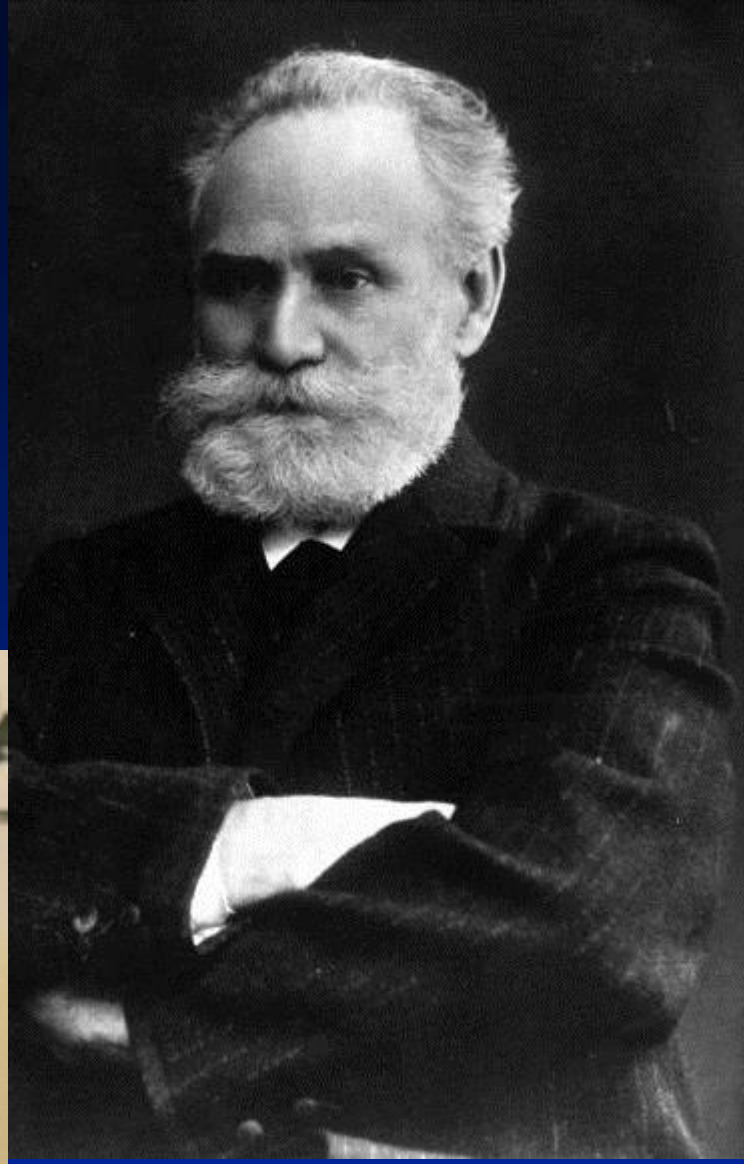
Cephalic Phase Responses

Sensory stimulation from foods lead to rapid activation of physiologic processes at multiple sites that may optimize the digestion, absorption, and use of ingested nutrients.



Nobel Prize in Physiology or Medicine 1904

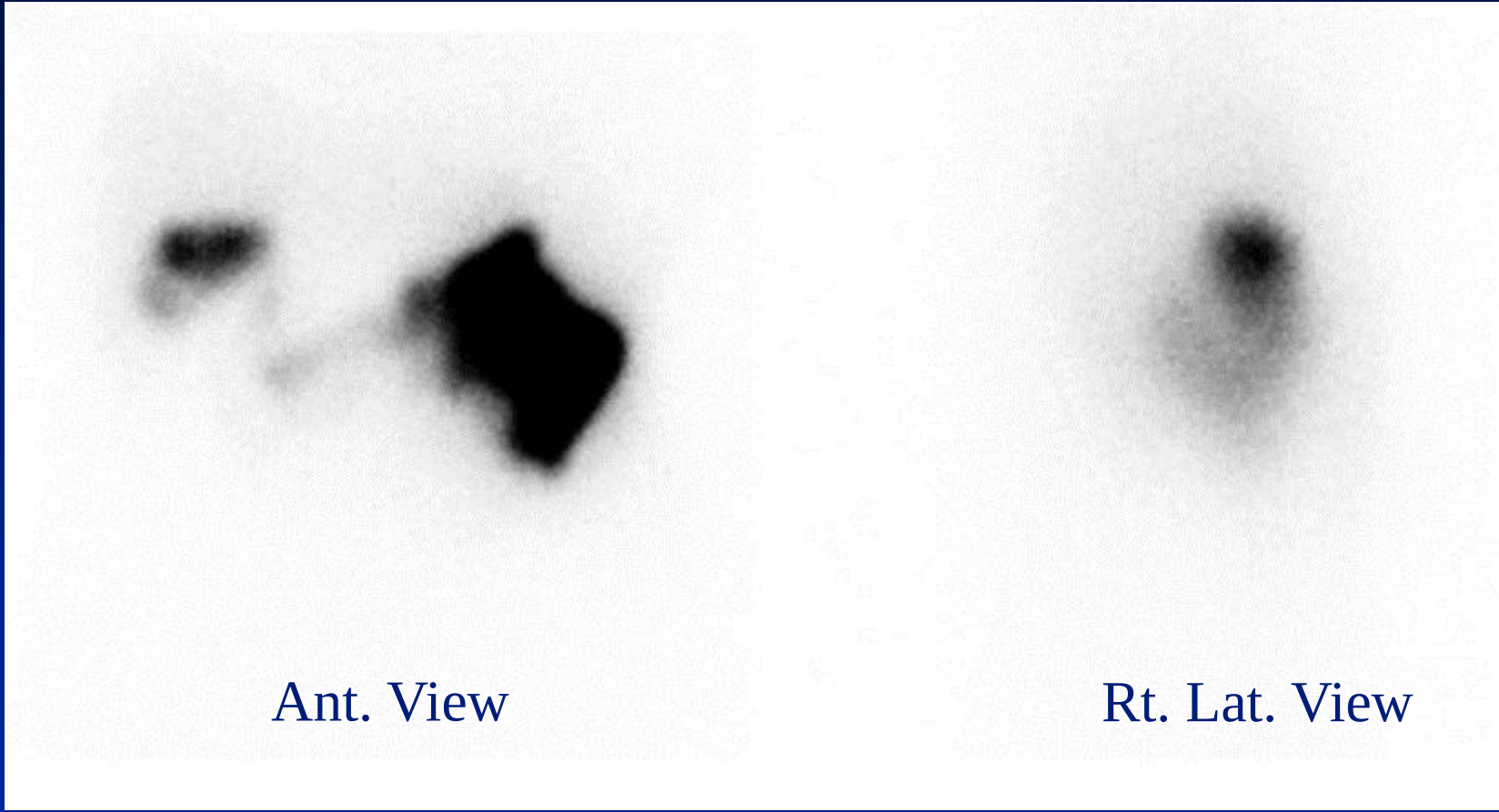
One of Pavlov's dogs (possibly "Baikal"), preserved at The Pavlov Museum, Ryazan, Russia



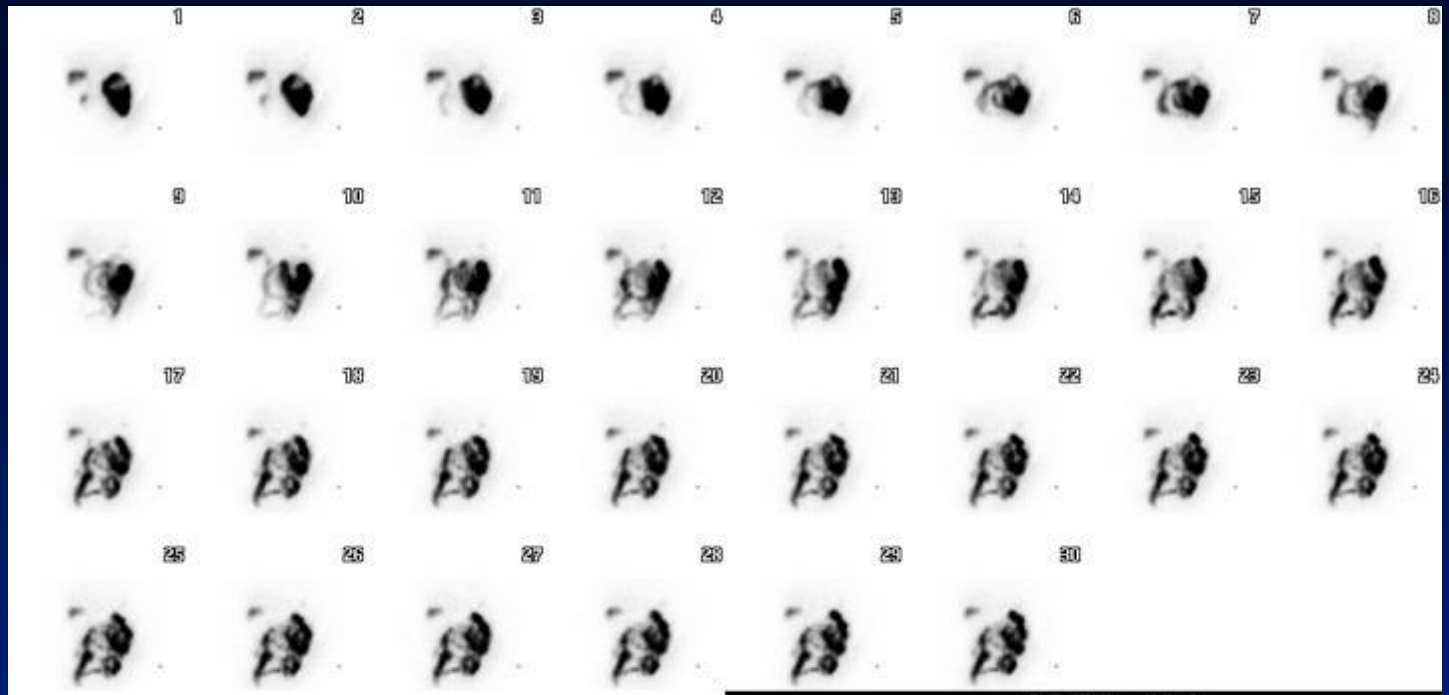
Ivan Petrovich Pavlov
Иван Петрович Павлов

Make sure videos offered to patients are not too stimulating!

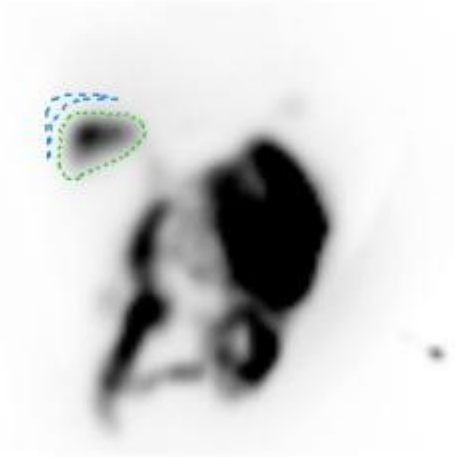
Repeat images at 1 hour and 15 minutes



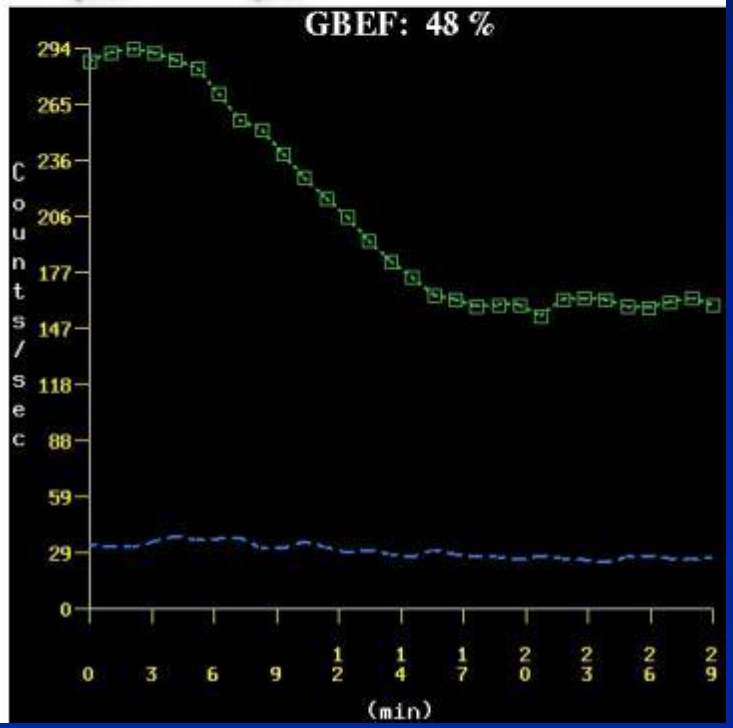
Case 7



Sincalide Cholescintigraphy

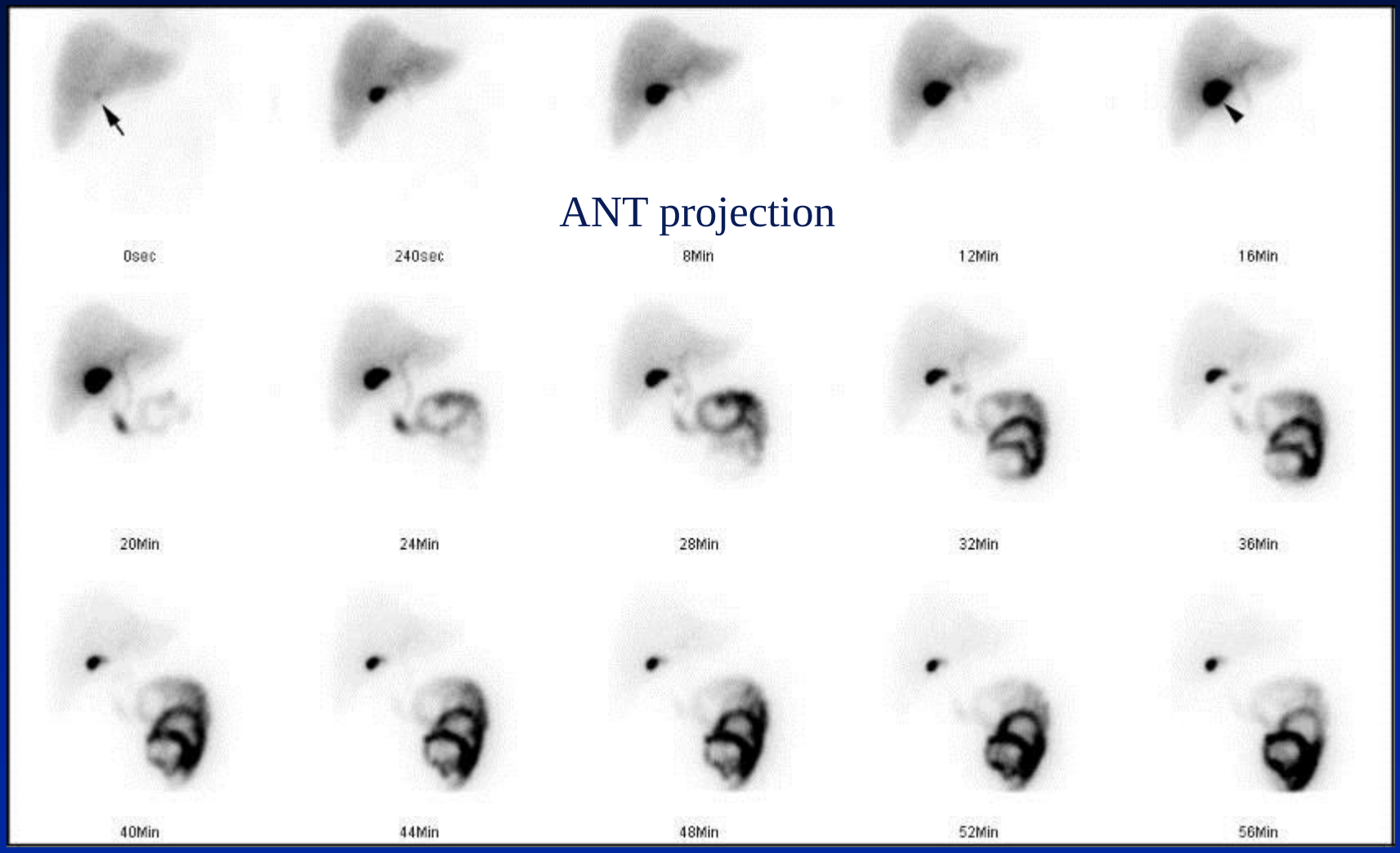


Images 1 through 30



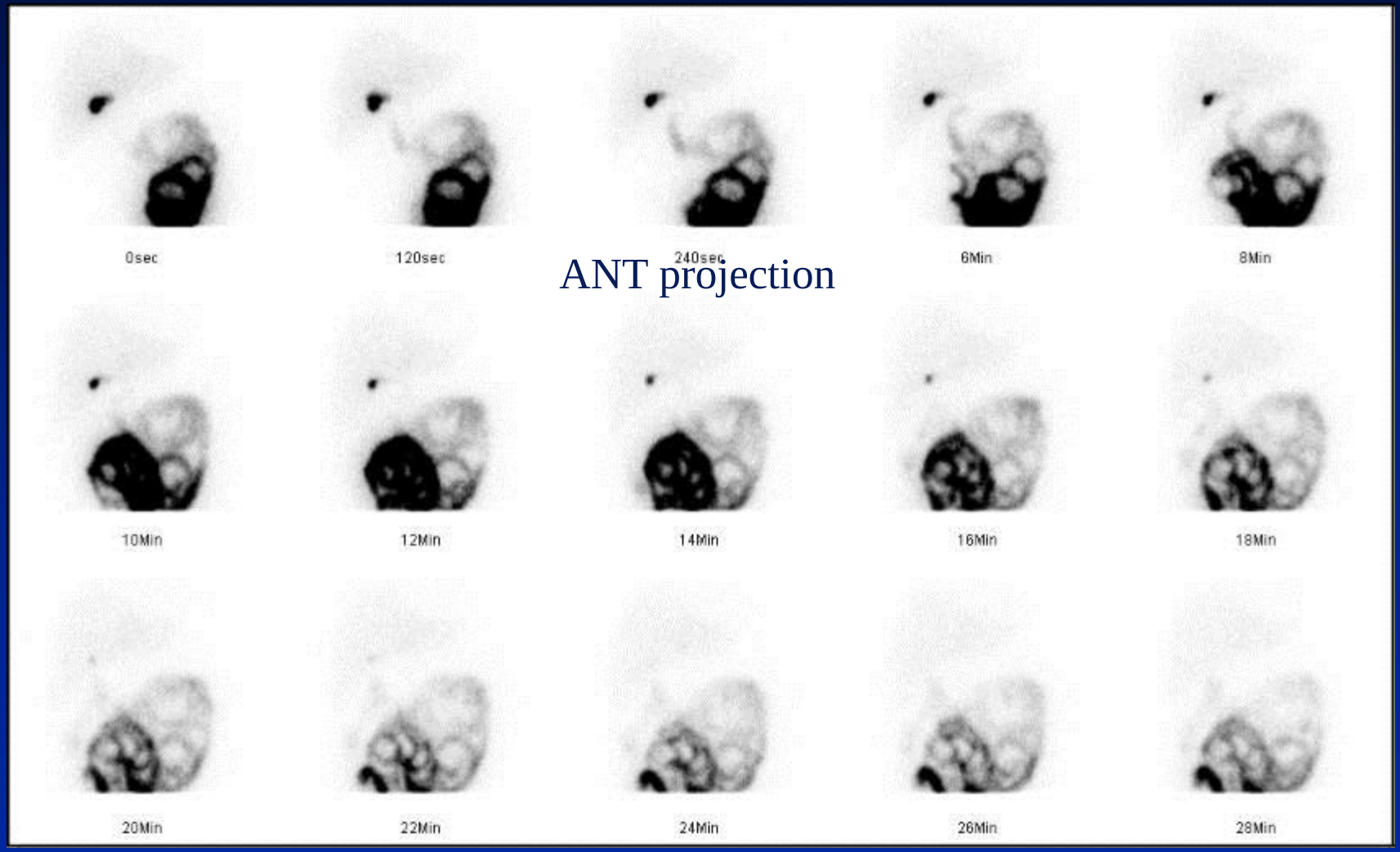
Case 7

25-year-old man was referred for chronic right upper quadrant abdominal pain for hepatobiliary scintigraphy to evaluate (GB) function.



GB Curve: Baseline Imaging

25-year-old man was referred for chronic right upper quadrant abdominal pain for hepatobiliary scintigraphy to evaluate (GB) function.



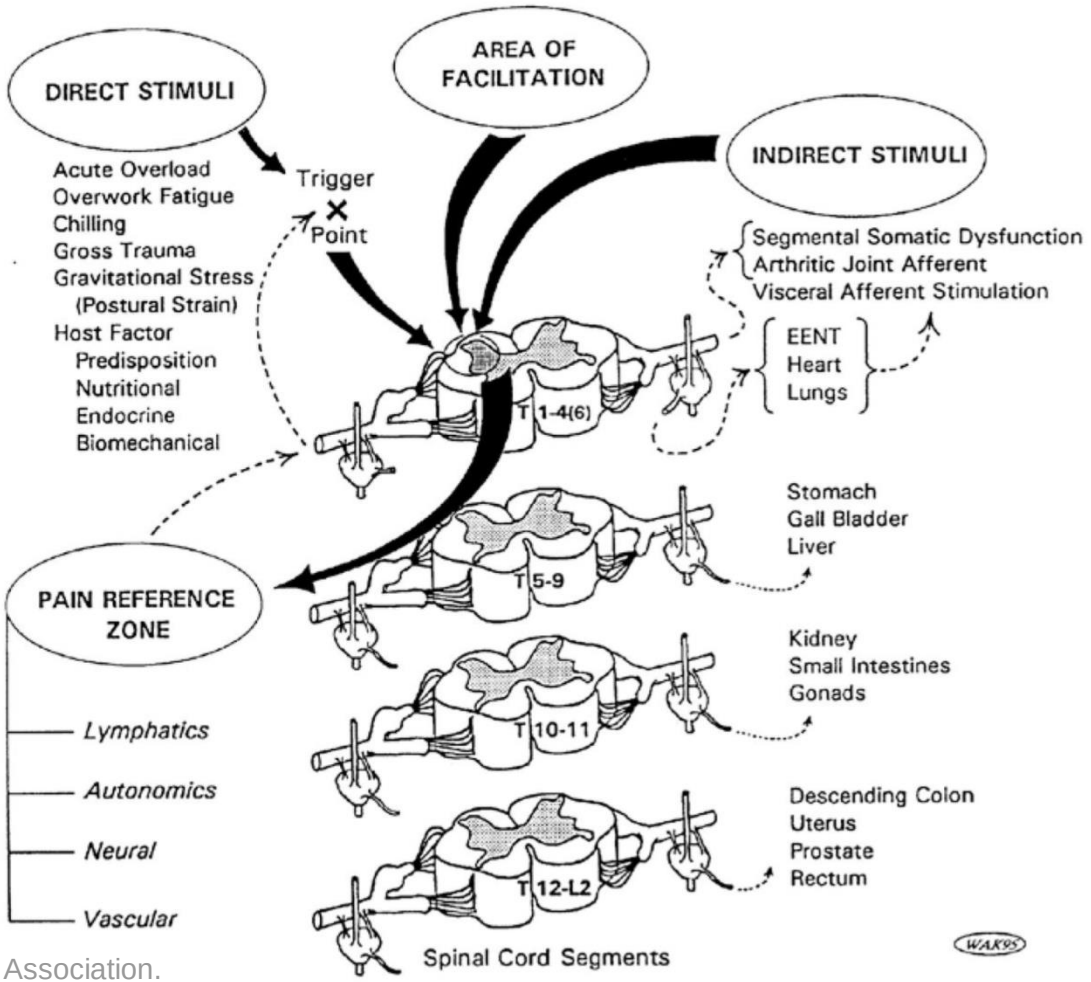
GB Curve, Sincalide Infusion

The Journal of the American Osteopathic Association
Established 1901

From: **An Osteopathic Approach to Gastrointestinal Disease: Somatic Clues for Diagnosis and Clinical Challenges Associated With Helicobacter pylori Antibiotic Resistance**

J Am Osteopath Assoc. 2013;113(5):404-416. doi:10.7556/jaoa.2013.113.5.404

Figure Legend: Illustration of the spinal cord in its role as a "neurologic lens" for a variety of stressors that can initiate somatic or visceral symptoms. Abbreviation: EENT, eye, ear, nose, and throat. Reprinted with permission from Kuchera ML, McPartland JM. Myofascial trigger points. In: Ward RC, executive ed. Foundations for Osteopathic Medicine. Baltimore, MD: Lippincott Williams & Wilkins; 1997:916.



What is a DO?
How Are DOs Licensed?
How Are DOs Certified?

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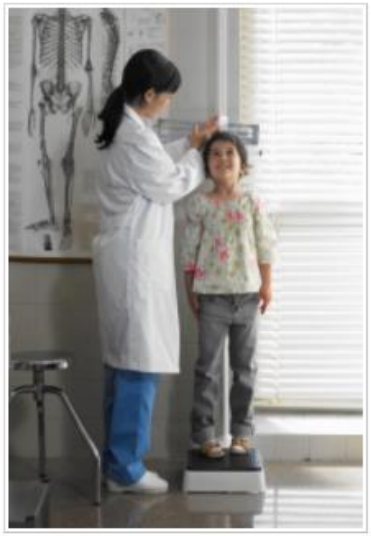
Becoming a DO

Video Library

What is Osteopathic Medicine?

What is a DO?

Doctors of Osteopathic Medicine, or DOs, are fully licensed physicians who practice in all areas of medicine. Emphasizing a whole-person approach to treatment and care, DOs are trained to listen and partner with their patients to help them get healthy and stay well.



DOs receive special training in the musculoskeletal system, your body's interconnected system of nerves, muscles and bones. By combining this knowledge with the latest advances in medical technology, they offer patients the most comprehensive care available in medicine today.

Osteopathic physicians focus on prevention, tuning into how a patient's lifestyle and environment can impact their wellbeing. DOs strive to help you be truly healthy in mind, body and spirit -- not just free of symptoms.

Learn more about the DO difference.

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Osteopathy

From Wikipedia, the free encyclopedia

For the American medical practice of osteopathic physicians in the United States, see Osteopathic medicine in the United States. For diseases of the bone, see bone disease and osteology.

Osteopathy is a type of alternative medicine and pseudomedicine that emphasizes massage and other physical manipulation of muscle tissue and bones.[1][2] Practitioners of osteopathy are referred to as osteopaths.[3][4][5] Its name derives from Ancient Greek "bone" (ὀστέον) and "sensitive to" or "responding to" (-πάθεια).[6][7][8]

This article is part of a series on
Alternative and pseudo-medicine

General information [hide]

Alternative medicine · Quackery ·


EAGLES
DESPERADO

Thank You For Your Attention!

Special Thanks to My Penn State Colleagues!

Joe Fotos Scott Winner Tom Allen