

Decreasing False Positives On Imaging: Is It Feasible?

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Definitions of “Positive”

SCREENING MAMMOGRAPHY

- Screening recall: BI-RADS*0=positive
 - If BI-RADS 3 is used in screening, it is also a positive (Use is discouraged!)
 - Online or delayed interpretation does not matter in “positive” classification
 - In MQSA Final Rule, positive exams are limited to those where tissue diagnosis is recommended
-

Definitions of “Positive”

SCREENING ULTRASOUND

- Recording of additional diagnostic images causes a screening US to be considered positive for auditing purposes, whether or not separate screening and diagnostic reports are issued
- Applies to all hand-held transducer exams, regardless whether performed by physician or technologist.
- Recall for additional exam from automated breast US exam is considered positive.

Definitions of “Positive”

SCREENING MRI

- Usually no difference in the images recorded for screening or diagnosis as BI-RADS*4 & 5 are given at screening
- Cases given a BI-RADS*0 should be considered positive
- BI-RADS*3 may be used at screening and is considered positive

Definitions of “Positive”

- POS DIAGNOSTIC EXAM (M, US, MRI)
- Tissue diagnosis is recommended BI-RADS categories 4 or 5

NEG DIAGNOSTIC EXAM (M,US, MRI)

- Tissue diagnosis is not recommended BI-RADS categories 1,2,or 3
- Note BI-RADS 3 is positive at screening
(recommendation for additional imaging before routine screening)

False positive definitions

- FP_1 = No known tissue diagnosis of cancer within 1 year of a positive screening examination (BI-RADS* 0)

M, US, MRI
Screening recall

No cancer one year

False positive definitions

- FP_2 = No known tissue diagnosis of cancer within 1 year after recommendation for tissue diagnosis or surgical consultation on the basis of a positive examination (BI-RADS* 4 or 5)

M, US, MRI
Diagnostic recall

No cancer one year

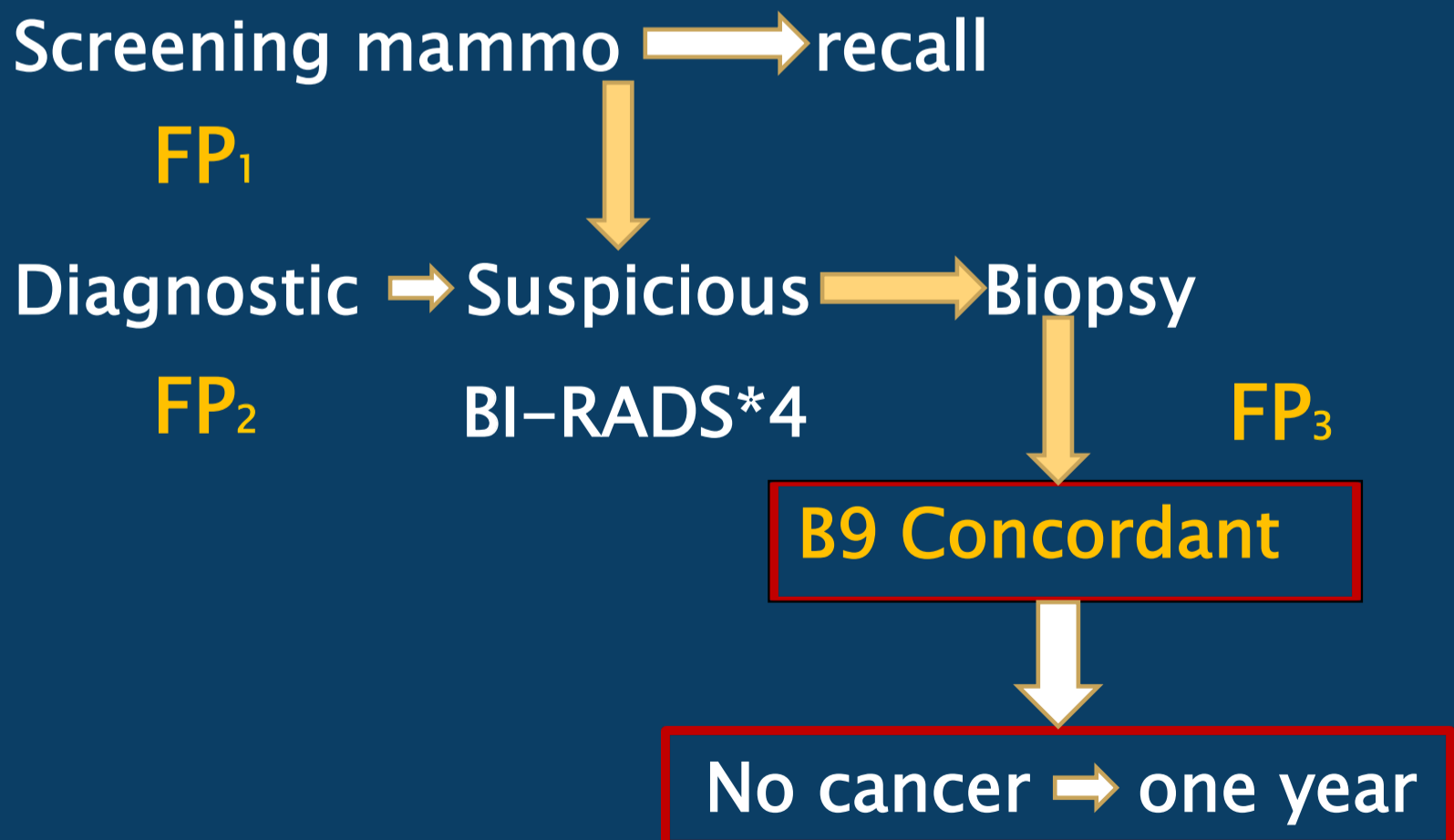
False positive definitions

- FP_3 = Concordant benign tissue diagnosis (or discordant benign tissue diagnosis and no known tissue diagnosis of cancer) within 1 year after recommendation for tissue diagnosis on the basis of a positive examination (BI-RADS 4 or 5).

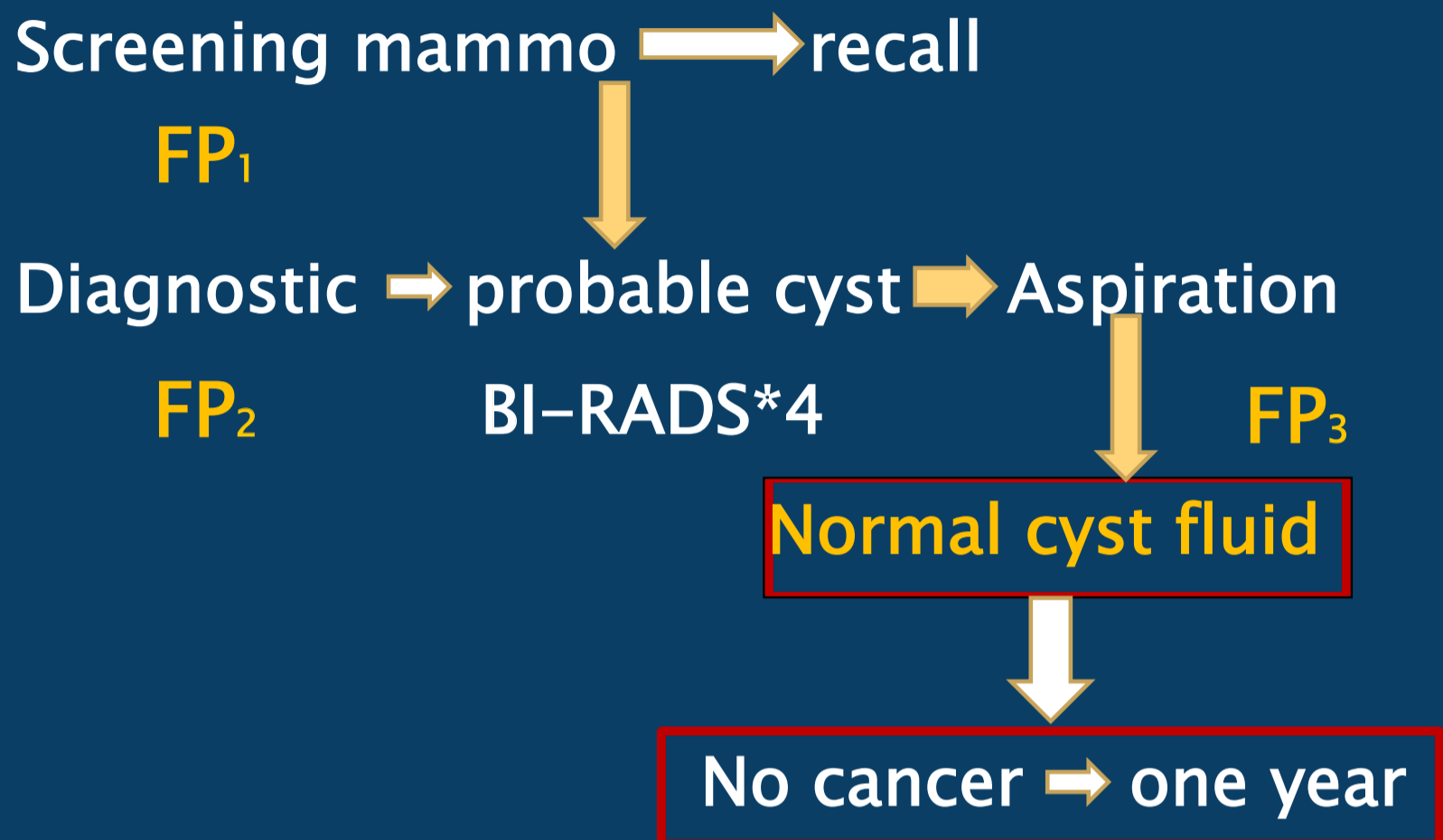
M, US, MRI
B9 concordant bx

No cancer w/i one year

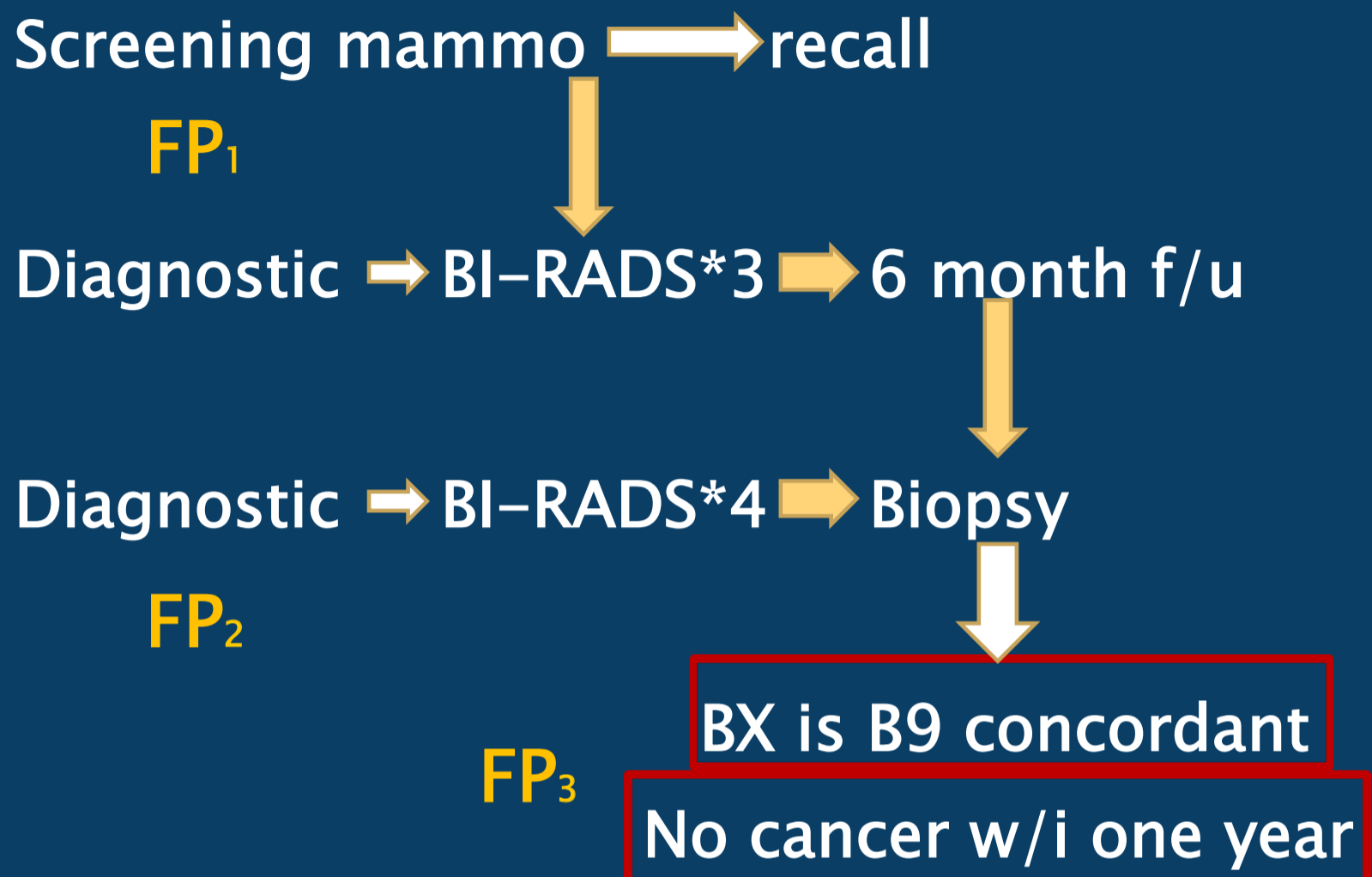
False positive examples



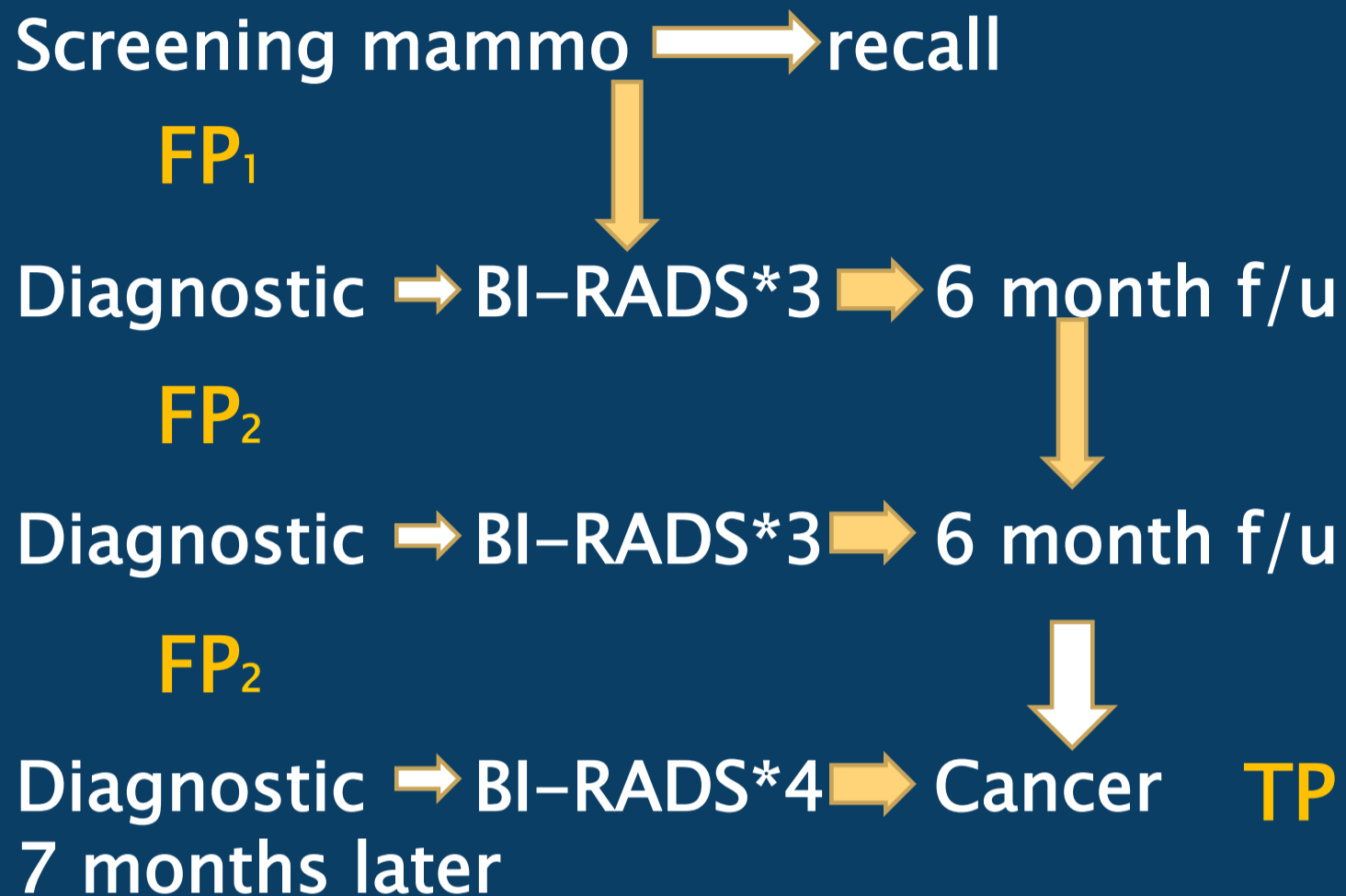
False positive examples



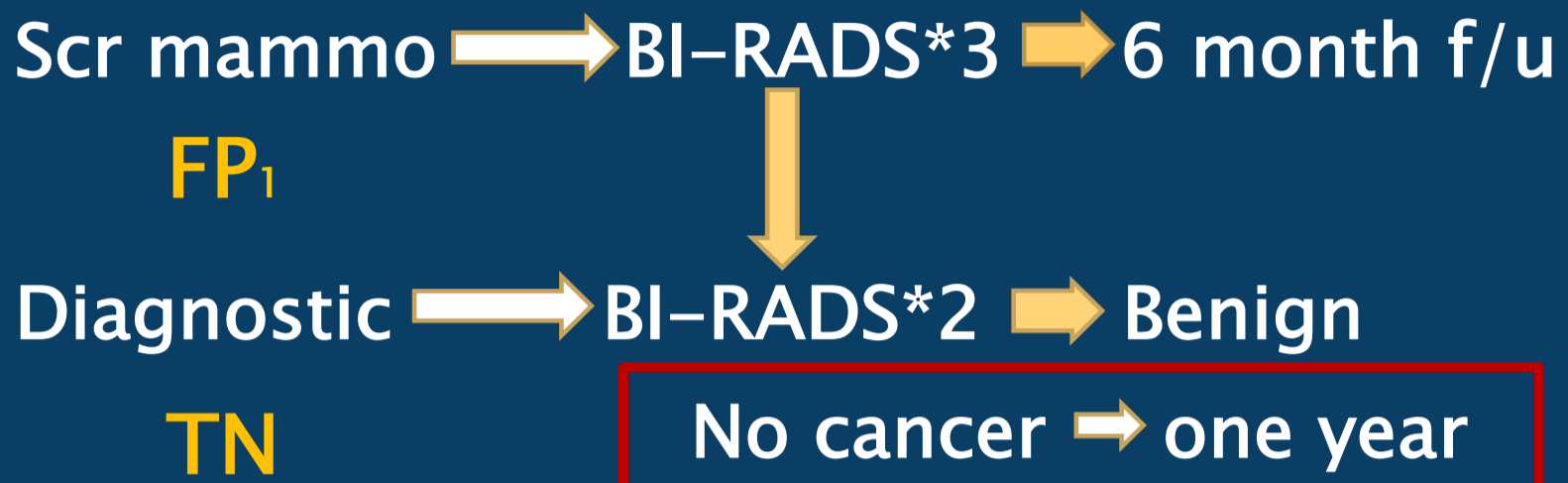
False positive examples



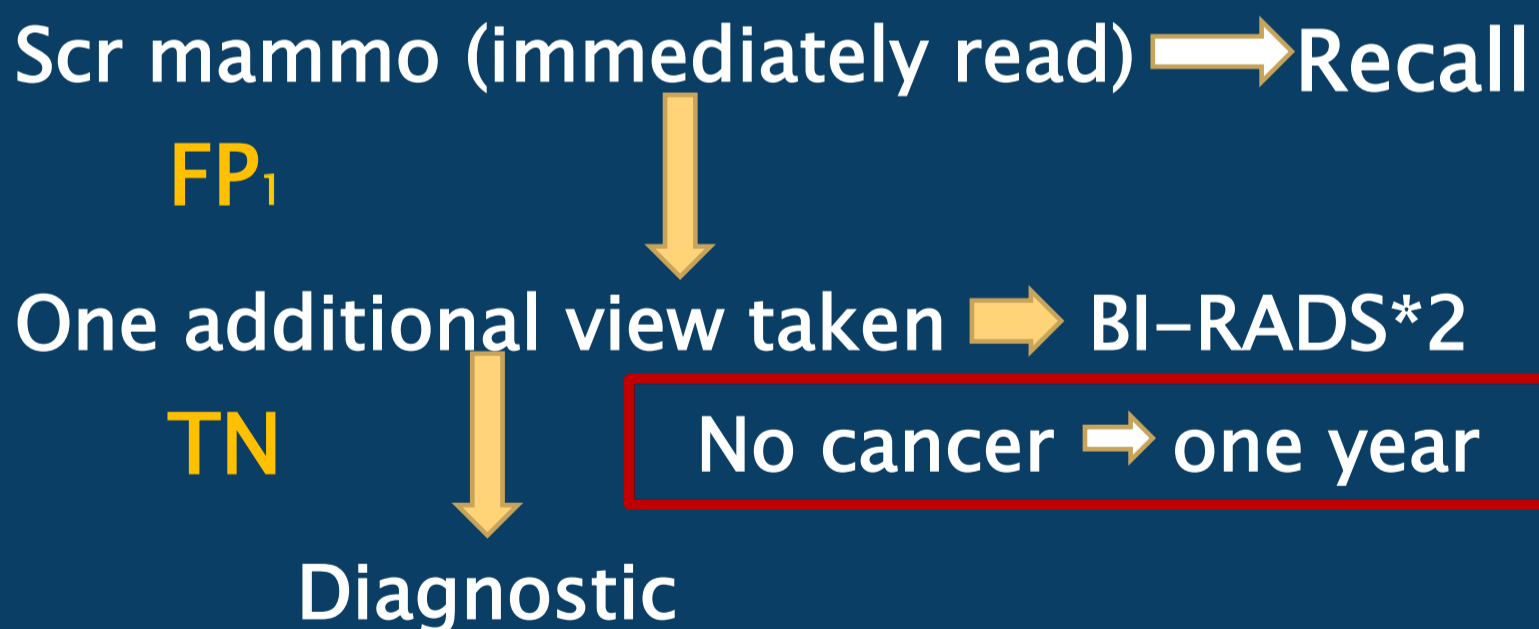
False positive examples



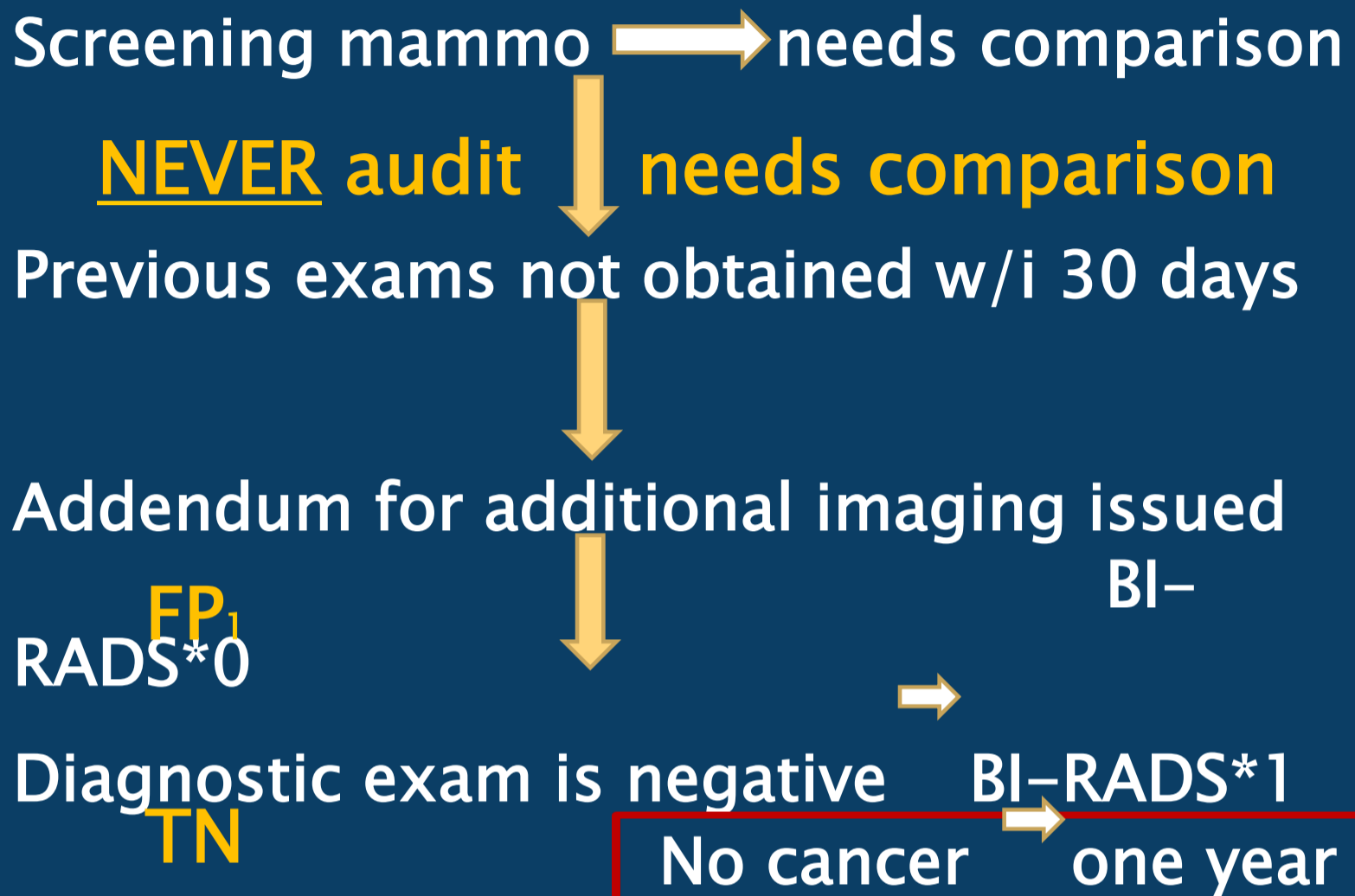
False positive examples



False positive examples



False positive examples



False positive examples

Diagnostic mammo-palp mass, **RT** breast

FN-FDA

Mammo read \Rightarrow suspicious mass, **LT** breast

FP₂-FDA

Biopsy **RT** breast \Rightarrow Cancer

Biopsy **LT** breast \Rightarrow Benign, Concordant

TP-MQSA

No cancer \Rightarrow one year

MQSA requires only a single assessment for both breasts on all mammography exams, but the FDA allows separate breast assessment under certain circumstances.

False positive examples

Mammo–suspicious finding, BI–RADS 4
LT breast, 3:00 **FP₂**

Found to be benign, concordant at biopsy

However, within a year, an unsuspected
cancer is found elsewhere in the
same breast **FN** **TP**

**FDA does not allow abnormality–level
assessments to replace a separate breast–
level assessments in the mammo report.**

False positive examples

Screening US  focal posterior acoustic shadowing on one of the recorded images



Screening part



FP₁

Further scan by physician to determine if finding is significant. Finding is not reproducible and images are recorded.



Diagnostic part

TN

False positive examples

Screening US  A simple cyst is shown on one of the recorded images.



Screening part



FP₁

Further scan by physician confirms finding is a cyst and images are recorded.



Diagnostic part

TN

If the physician found at repeat scanning that the lesion was a benign cyst and did not record additional images, then the exam would be audited as a **TN**.

Decreasing False Positives

SCREENING MAMMOGRAPHY (FP₁)

What is the false positive rate?

Cumulative Probability of False Positive Recall or Biopsy Recommendation After 10 years of Screening Mammography: A Cohort Study. *Ann Intern Med.* 2011; 155(8):481–492.

61% FP mammogram and 7–9% FP biopsy over 10 years
6.1% FP mammogram/yr and 0.7–0.9% FP biopsy/yr

Influence of Annual Interpretive Volume on Screening Mammography Performance in the United States. *Radiology.* Apr 2011; 259(1): 72–84

BSCS radiologists (120) mean FP rate **9.1%**

$$\underline{TP} + \underline{TN} + \underline{FP} + \underline{FN} = \underline{\text{No. of exams}}$$

Decreasing False Positives

SCREENING MAMMOGRAPHY (FP₁)

$$\underline{TP} + \underline{TN} + \underline{FP} + \underline{FN} = \underline{\text{No. of exams}}$$

$$5 + 900 + 90 + 5 = 1000$$

$$(0.5\%) \quad (90\%) \quad (9.0\%) \quad (0.5\%)$$

The FN rate is at least
the same as the TP rate!

Decreasing False Positives

SCREENING MAMMOGRAPHY (FP₁)

- Decrease the callbacks (FP)
 - Increase the number of cancers detected (TP)
 - Never decrease callbacks at the expense of missing cancers
-

Decreasing False Positives

SCREENING MAMMOGRAPHY (FP₁)

- 120 BSCS Radiologists who interpreted 783,965 screens from 2002-2006
- The mean FP1 rate was 9.1% (CI:8.1-10.1%) with rates significantly higher for radiologists who had the lowest total and lowest screening volumes
- Radiologists with lower screening volumes and higher diagnostic volumes had higher FP rates.
- The lowest FP rates (5.6%) were among radiologists with a screening focus of 90% or greater, and this same group had the lowest CDRs (3.4/1000)

Influence of Annual Interpretive Volume on Screening Mammography Performance in the United States. *Radiology*. Apr 2011; 259(1): 72-84

Decreasing False Positives

SCREENING MAMMOGRAPHY (FP₁)

- The highest FP rates (10.7%) and CDRs (4.8/1000) were among radiologists with a screening focus of less than 80%
- Radiologists with a screening focus of >90% recalled a mean of 14.5 women for each cancer detected but had lower sensitivity than radiologists with lower screening focus percentages
- Radiologists with a screening focus of <80% had higher sensitivity but recalled 23.8-27.0 women per cancer detected
- Based on the data, a simulation was performed, on the basis of: 34 million women, aged 40-79 screened yearly, and the effect of increasing the number of mammograms interpreted/year

Influence of Annual Interpretive Volume on Screening Mammography Performance in the United States. *Radiology*. Apr 2011; 259(1): 72-84

Decreasing False Positives

SCREENING MAMMOGRAPHY (FP₁)

Annual Minimum Volume

Total Mammo Volume	Fewer Recalls	Cancers Missed	Cancers Detected
≥1000	43,629	40 (0.03%)	143,215
≥1500	92,838	761 (0.53%)	142,494

Screening Volume	Fewer recalls	Cancers missed	Cancers Detected
≥1000	71-110	415 (0.29%)	141,413
≥1500	117,187	315 (0.22%)	141,467

Influence of Annual Interpretive Volume on Screening Mammography Performance in the United States. *Radiology*. Apr 2011; 259(1): 72-84

Decreasing False Positives

SCREENING MAMMOGRAPHY (FP₁)

- No clear association between volume and sensitivity
- Higher interpretative volume is associated with clinically and statistically important lower rates of FP and numbers of women recalled per cancer detected—without a corresponding decrease in sensitivity or CDR
- Lower CDRs in radiologists with lower diagnostic volumes
- Performance had wide, unexplained variability—volume/performance relationship is complex

Influence of Annual Interpretive Volume on Screening Mammography Performance in the United States. *Radiology*. Apr 2011; 259(1): 72–84

Decreasing False Positives

The Agony of Screening—Can't Decide

"To recall or not to recall "

Pretend you are in noon conference

If someone showed you this case, and said, "We biopsied this lesion and it turned out to be cancer." Would you react by saying:

Of course!" or "I don't believe it?"

Now you will know what to do.

Decreasing False Positives

Comparison of Digital Mammography alone and Digital Mammography plus Tomosynthesis

- Mammo (M) alone cancer detection rate alone was 6.1/1000
- Mammo plus tomosynthesis (T) was 8.0/1000 (31%)
- The false positive rate was 15% less with M+T



FP rates mammo alone= 61.1 /1000

- Prospective, single institution study analyzing results from 12,631 examinations

FP rates mammo+tomo+=53.1 /1000

Skane et al. Radiology. Published online before print January 7, 2013,doi: 10.1148/radiol.12121373

Decreasing False Positives

Tomosynthesis

- Significantly lower recall rates
 - *BI-RADS density groups 2,3, 4
 - *<40 y/o
 - *40-49 y/o
 - *50-59 y/o
 - *60-69 y/o

Haas B et al. Radiology 2013:269, Issue 3

Decreasing False Positives

Tomosynthesis

- Significantly lower recall rates
 - *Asymmetries
 - *Calcifications

Durand et al. Radiology, January 2015:274, Issue 1

Decreasing False Positives

SCREENING MAMMOGRAPHY (FP₁)

- Learn the subtle signs of malignancy
 - Learn the limits of normal variation
 - Read the questionnaire
 - Read prior reports
 - Ensure proper viewing conditions
 - Batch interpretation/employ a scribe
-

Decreasing False Positives

SCREENING MAMMOGRAPHY (FP₁)

- View images back to back
- Overall and close-in search
- Beware of satisfaction of search
- Concentrate on white parts
- Search for one calcification/artifact
- Compare with 2 priors/beware of the seduction of stability

Decreasing False Positives

SCREENING MAMMOGRAPHY (FP_1)

READ MORE MAMMOGRAPHY!

USE TOMOSYNTHESIS!

Decreasing False Positives

SCREENING MAMMOGRAPHY (FP_1)

- Difficult to separate US FP_1 and FP_2
- Recording of additional diagnostic images causes a screening US to be considered positive for auditing purposes, whether or not separate screening and diagnostic reports are issued
- Recall for additional exam from automated breast US exam is considered positive

Decreasing False Positives

Screening Ultrasound—ACRIN 6666

	US only	Mammo only
Biopsy Rate		
Year 1 (P)	8.8% (233/2659)	2.4% (65/2659)
Year 2–3 (I)	5.5% (266/4814)	2.0% (97/4814)
PPV3		
Year 1 (P)	9.0% (21/233)	29.2% (19/65)
Year 2–3 (I)	11.7% (31/266)	38.1% (37/97)
FP₂		
Year 1 (P)	8.0% (212/2659)	1.7% (46/2659)
Year 2–3 (I)	4.9% (235/4814)	1.3% (60/4814)

Decreasing False Positives

Screening Ultrasound—ACRIN 6666

	US only	Mammo only
BI-RADS 3 Rate		
Year 1 (P)	11.1% (296/2659)	3.3% (84/2659)
Year 2–3 (I)	3.9% (190/4814)	1.6% (76/4814)

BI-RADS 3 used at screening is a positive !

**Reading more US decreases positive rate
or**

Most of the positives have been found

Decreasing False Positives

Screening Ultrasound

- New or enlarging solid mass → Biopsy
 - Dominant or palpable mass → Biopsy
 - 2.4% of women (2/82) in ACRIN 6666 with multiple bilateral circumscribed masses also had cancer seen only on US
-

Decreasing False Positives

Screening MRI—ACRIN 6666

	Mammo +Sono	Addition of MRI
Percentage of Women Biopsied After 3 screens	6.2% (38/612)	13.2% (81/612)
PPV3 After 3 screens	18.4% (7/38)	18.5% (15/81)

Decreasing False Positives

BREAST MRI SCREENING (FP₃)

	<u>BI-RADS 4,5 Rates</u>	<u>FP %age</u>
Baseline	16/18 -> 2 cancers	89%
Comparison	13/16 -> 3 cancers	81%

Abramovici G & Mainiero M. Radiology, Apr 2011; vol 259, issue 1

Decreasing False Positives

BREAST MRI (FP₂)

- DCE and DWI-MRI: Apparent Diffusion Coefficient (ADC) Threshold
- 46% (81/175) nonmalignant lesions above threshold
- High risk lesions were the most common nonmalignant lesion below threshold [79% (22/28)]
- Lesions have considerable overlap

Parsian S et al. Radiology, Dec 2012; vol 265, issue 3

Decreasing False Positives

BREAST MRI (FP₂)

- Confirm true enhancement is present and not an artefact
- Recognize normal enhancing structures
- Analyze enhancement (ACR BI-RADS lexicon)
- Be able to characterize benign lesions

Millet I et al. Br J Radiol. 2012 Mar; 85 (1011):197-207.

Decreasing False Positives

BREAST MRI (FP₂)

- **Confirm true enhancement vs. artefact**

Pseudoenhancement on subtracted images

Due breast movement between pre- and post-contrast

Easy to see if in plane of the slice

Two adjacent artefacts: one bright, one dark

More difficult if not in same plane of acquisition

Millet I et al. Br J Radiol. 2012 Mar; 85 (1011):197-207.

Decreasing False Positives

BREAST MRI (FP₂)

- Recognize normal enhancing structures

Vascular structures

Nipples

Intramammary lymph nodes

Breast parenchyma

Millet I et al. Br J Radiol. 2012 Mar; 85 (1011):197-207.

Decreasing False Positives

BREAST MRI (FP₂)

- Analyze enhancement (ACR BI-RADS lexicon) to accurately characterize benign lesions

Type of enhancement: mass v. non mass

Enhancement kinetics

Correlate with mammography and US

Millet I et al. Br J Radiol. 2012 Mar; 85 (1011):197-207.

Decreasing False Positives

IS IT FEASIBLE?

YES, IT IS FEASIBLE

BY INDIVIDUAL

BY SYSTEMS