Considerations in Cost-Effectiveness of Low-dose CT Screening with Imaging Processing Applications

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Overview

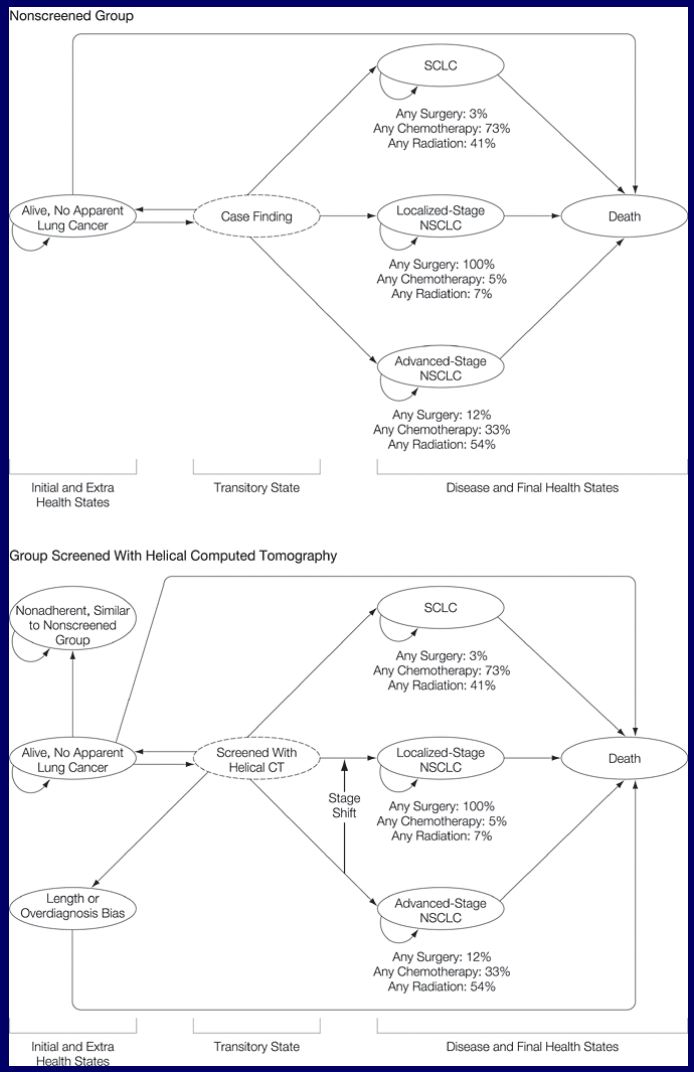
- Update on current evidence regarding the cost-effectiveness (CE) of lung cancer screening
- Potential roles of computer-aided diagnosis (CAD)
- Impact of CAD on the CE of lung cancer screening

Cost-effectiveness as a Guide to Resource Allocation

- CE is a method to evaluate the outcomes and costs of interventions designed to improve health
- Limited resources require efficient use
- Choices must be made between alternative use of resources
- Multiple perspectives
- Incremental CE ratio compared to the standard of care

Steps in the Evaluation of the Cost-effectiveness Screening

- Model
- Effectiveness
- Costs
- CE ratio
- Sensitivity analysis



Mahadevia, P. J. et al. JAMA 2003;289:313-322

CE Analyses of Lung Cancer Screening

- 7 studies
- US-based analyses
- Full economic evaluations
- Published 2001-2012

CE Analyses of Lung Cancer Screening

- LDCT screening vs. standard of care
- Most used pre-NSLT data
- Decision analytical models
- High risk populations (smokers)

Studies Evaluating the CE of LDCT

Study	Well-described Question	Perspective	Type of Analysis
Marshal 2001	✓	National payer	Incremental CEA
Marshal 2001	✓	National payer	Incremental CEA
Chirikos 2002	✓	National payer	Incremental CEA
Mahadevia 2003	✓	Societal	Incremental CEA
Wisnivesky 2003	✓	Health care system	Incremental CEA
McMahon 2011	✓	Societal	Incremental CEA
Pyenson 2012	✓	Commercial health insurance	Incremental CEA

Black C, et al. The clinical effectiveness and CE of computed tomography screening for lung cancer. HTA 2006.

Studies Evaluating the CE of LDCT

Study	Intervention	Population	Time Horizon
Marshal 2001	Baseline CT	60-74 years	5 years
Marshal 2001	5 annual CTs	60-74 years	5 years
Chirikos 2002	5 annual CTs	≥45-74 years	15 years
Mahadevia 2003	20 annual CTs	≥60 years	Death
Wisnivesky 2003	Baseline CT	≥60 years	Death
McMahon 2011	10-20 annual CTs	50-70 years	Death
Pyenson 2012	Annual CTs	50-64 years	-

Model Characteristics of Studies Evaluating the CE of LDCT

Study	Type of Model	Biased Included	Outcome
Marshal 2001	Decision Analysis	✓	Qualys
Marshal 2001	Decision Analysis	✓	Qualys
Chirikos 2002	Decision Analysis	-	Years of life saved
Mahadevia 2003	Markov Model	✓	Qualys
Wisnivesky 2003	Decision Analysis	✓	Years of life saved
McMahon 2011	Mathematical Model	✓	Qualys
Pyenson 2012	Actuarial Model	✓	Years of life saved

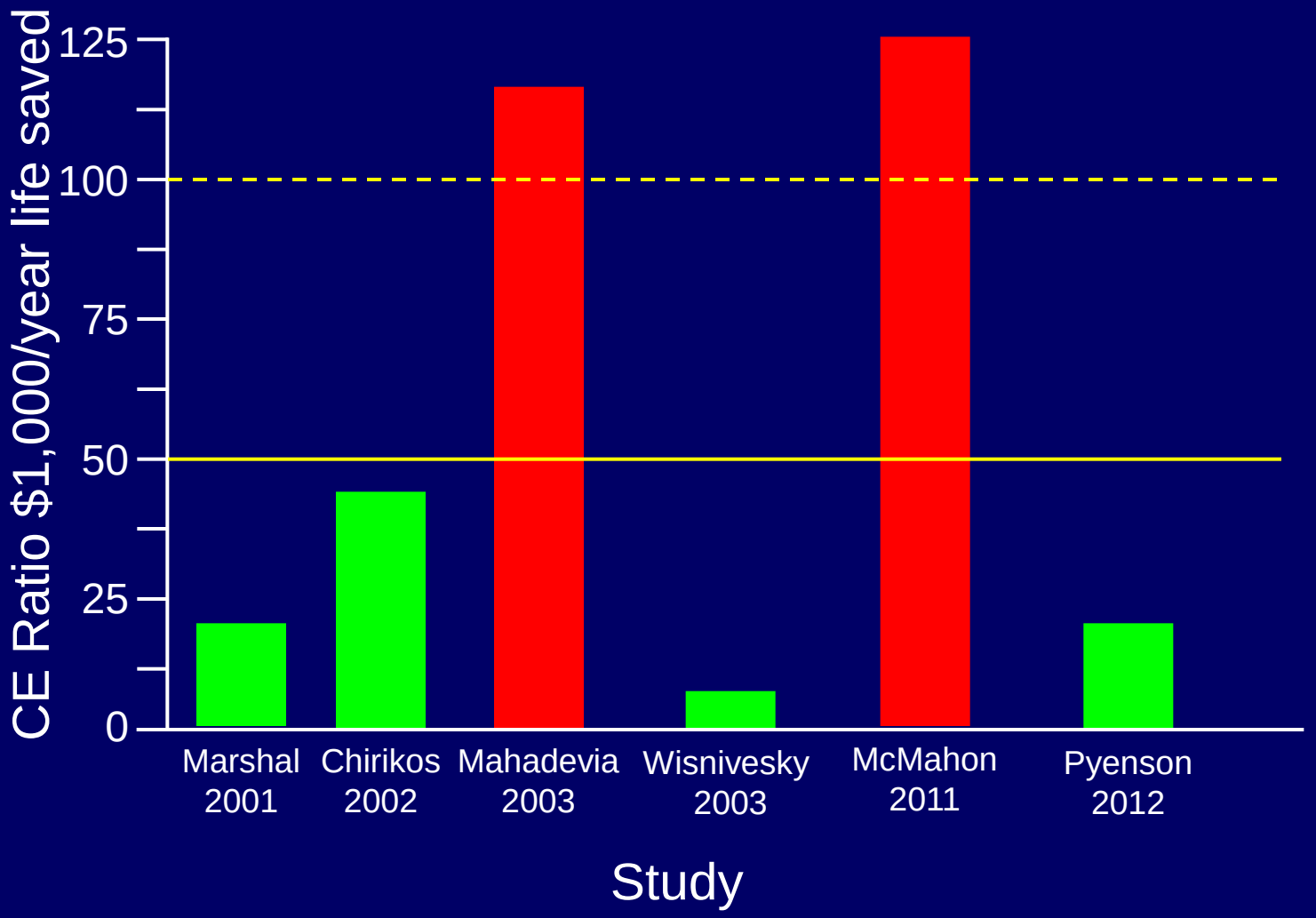
Costs and Cost Data Sources

Study	Source	Cost LDCT	Discount
Marshal 2001	Medicare	$150	3%
Marshal 2001	Medicare	$150	3%
Chirikos 2002	Medicare	$291	7.5%
Mahadevia 2003	Medicare	$300	3%
Wisnivesky 2003	Hospital Database	$165	3%
McMahon 2011	Medicare	~$200	3%
Pyenson 2012	Health insurance Medicare	$180	2012 costs

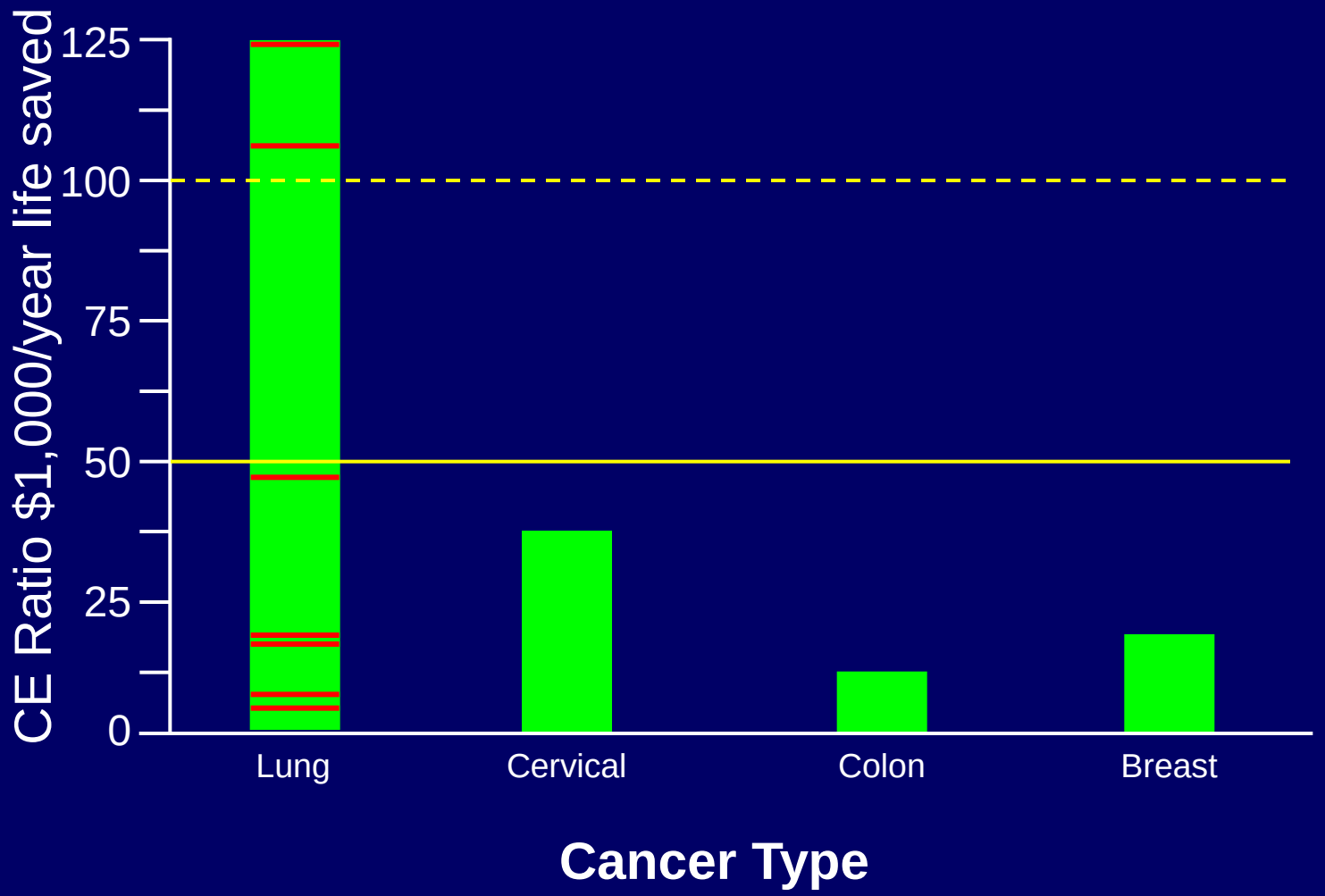
Health Outcomes Data

Study	Lung Cancer Prevalence	Lung Cancer Incidence	Early Cancer with LDCT (%)
Marshal 2001	2.7%	0.3%	85%
Marshal 2001	2.7%	0.3%	85%
Chirikos 2002	1.2%	0.7%	50%
Mahadevia 2003	0.8%	0.4%	60%
Wisnivesky 2003	2.7%	0.6%	80%
McMahon 2011	-	-	-
Pyenson 2012	0.6%	0.2%	-

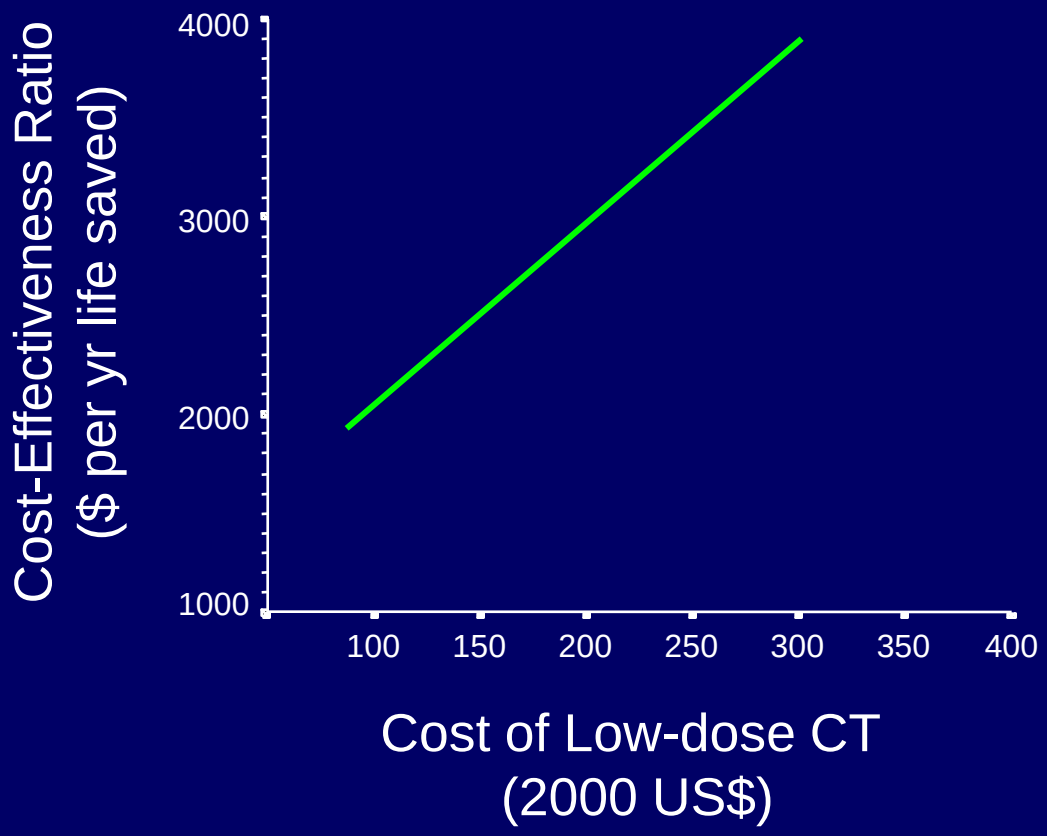
CE of Lung Cancer Screening with LDCT



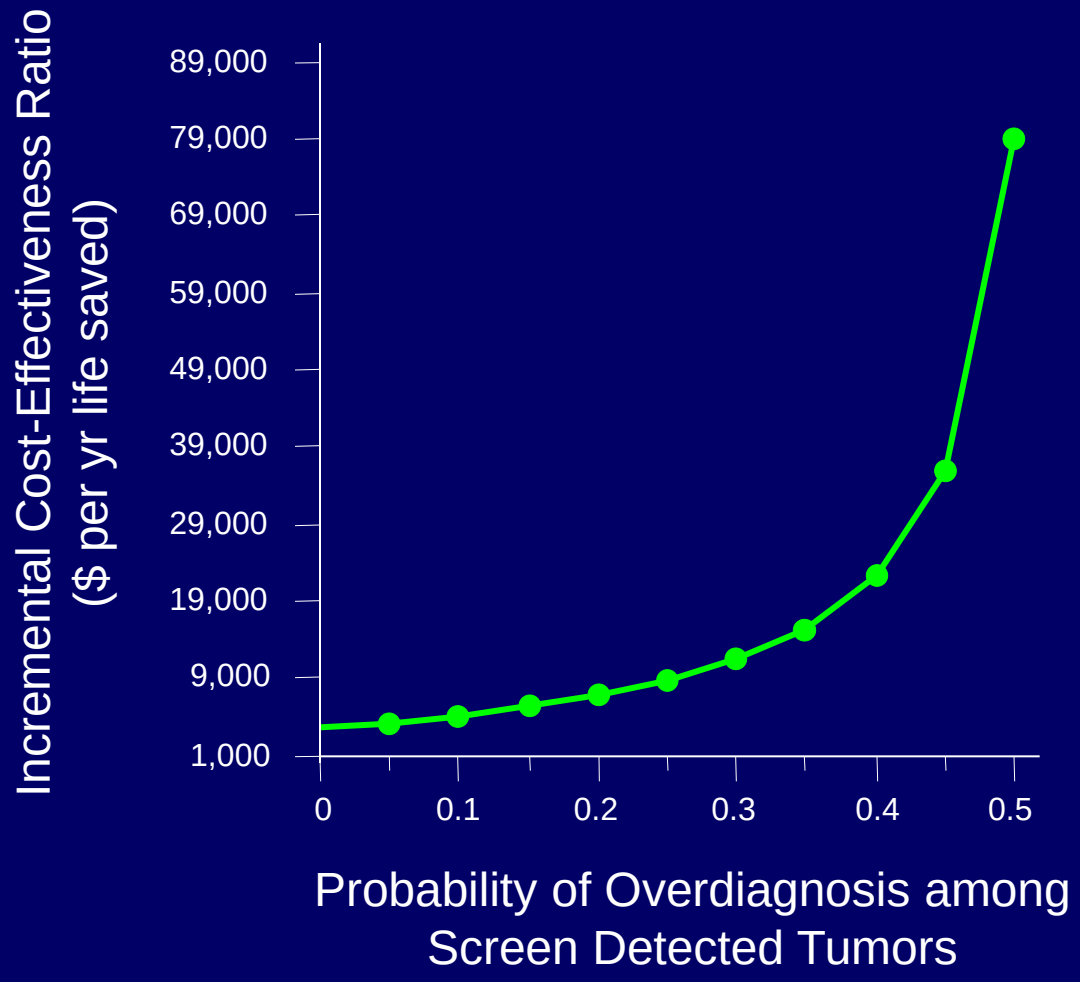
CE Ratio of Different Cancer Screening Tests



Sensitivity Analysis on the Cost of Low-dose CT



Effect of the Probability of Overdiagnosis among Screen Detected Tumors



Summary of CE Analyses of LDCT Screening for Lung Cancer

- Considerable variability on study design and assumptions
- Different perspectives
- Conclusions vary across studies
- Most results suggest that LDCT is cost-effective
- Awaiting results of additional studies

CAD and LDCT Screening: The Perfect Marriage?

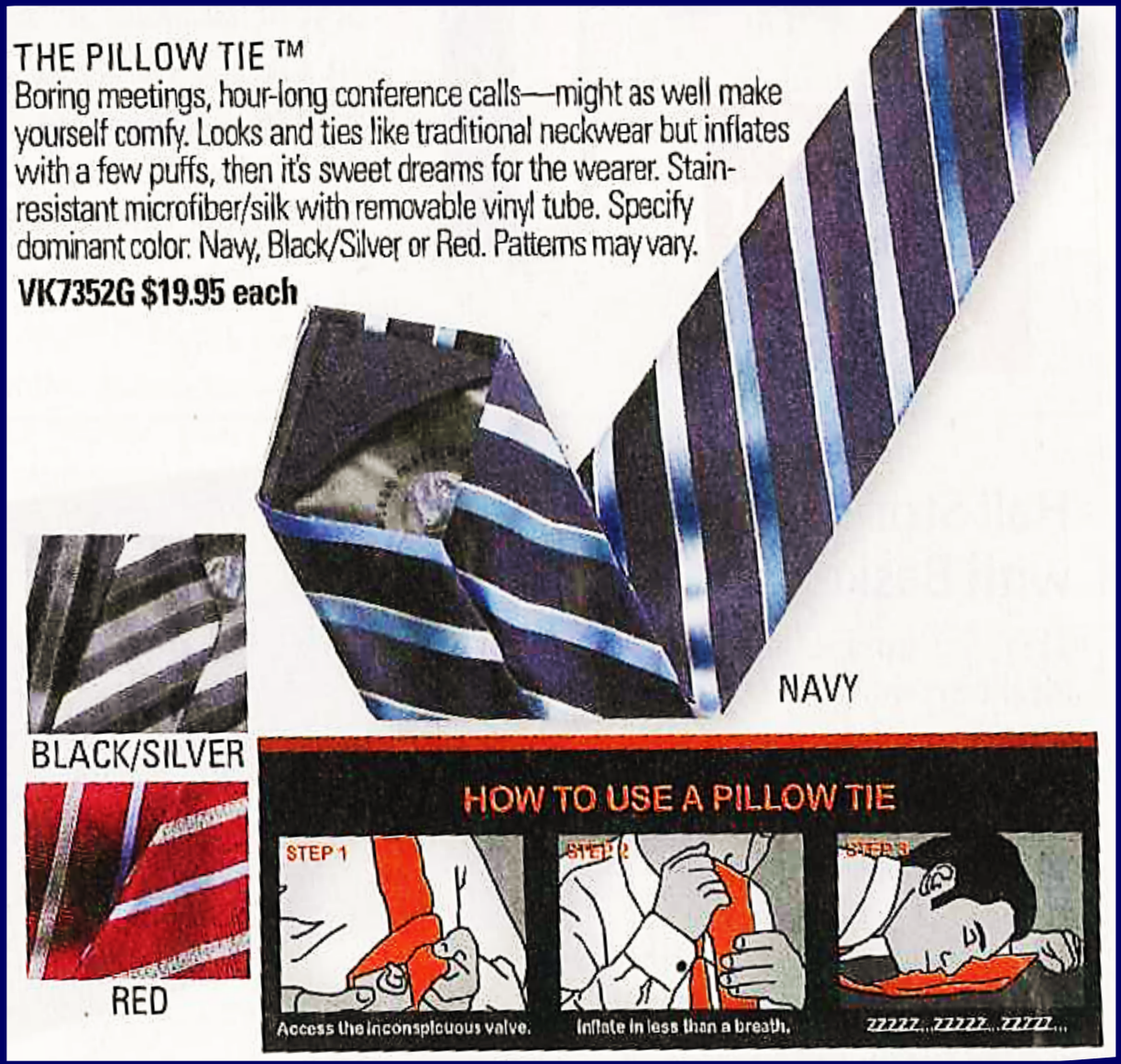
Potential Uses of CAD in Lung Cancer Screening

- Detection of nodules
- Volumetry Measurement
- Morphologic analysis of nodules
- Matching of nodules in serial studies
- Assessment of GGOs

CAD for Nodule Detection in Lung Cancer Screening

- First, concurrent, or second reader
- Pros:
  - increased sensitivity (<4-5 mm)
  - ↑ ~10%
- Cons:
  - may not help detect extra cancer cases
  - decreased specificity
  - increased reading time (~40 seconds per CT)

Warning Speculative Section: May Skip Without Lost of Continuity



Potential Consequences of Integrating CAD for Nodule Detection to LDCT Screening

No CAD

		Lung Cancer		
		Yes	No	Total
LDCT	+	120	2,280	2,700
	-	10	7,290	7,300
	Total	130	9,870	10,000

- Sensitivity: 92%
- Specificity: 74%

CAD

		Lung Cancer		
		Yes	No	Total
LDCT	+	123	2,863	2,986
	-	7	7,007	7,014
	Total	130	9,870	10,000

- Sensitivity: 95%
- Specificity: 71%

- Identify 3 additional cancers
- Perform 583 additional follow-up CTs
- 36 additional biopsies

Cost of LDCT Screening with and without Use of CAD for Nodule Detection

Savings				Additional Costs			
Event	**Number**	**Cost per event**	**Total Savings**	**Event**	**Number**	**Cost per event**	**Total Added Costs**
Early vs. late stage	2	$30,000	$60,000	Follow-up CTs	583	$200	$116,600
				Biopsies	36	$1,000	$36,000
				Radiologist Time	4 days	$5,000	$5,000
		Total	**$60,000**			**Total**	**$157,600**

The Possible Incremental CE Ratio of Integrating CAD to LDCT Screening

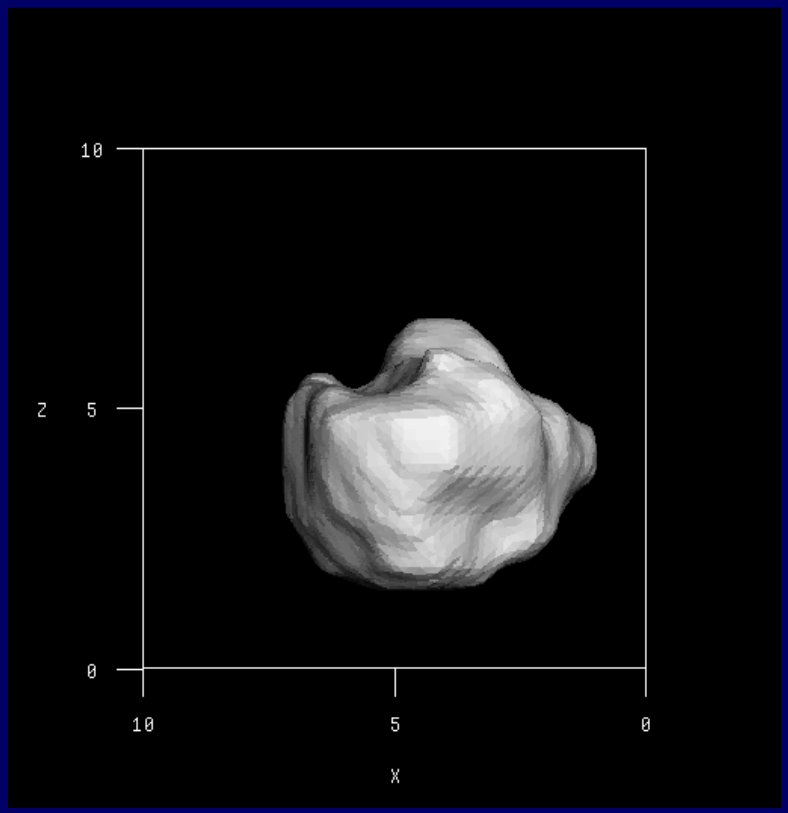
- 2 cancers diagnosed as early vs. late disease
- 60 year old: add ~15 years

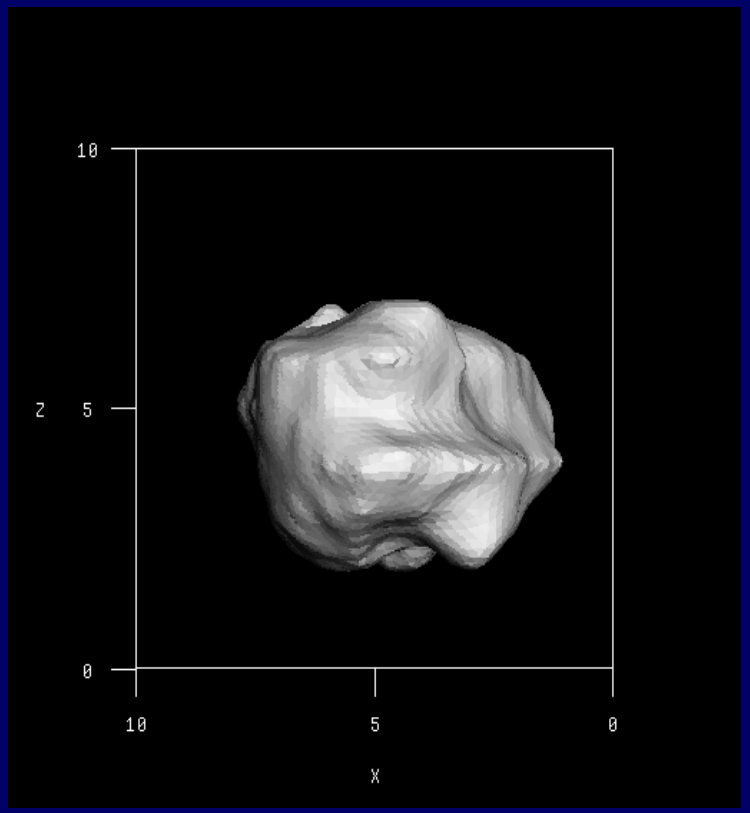
$$\text{ICER} = \frac{\$157{,}600 - \$60{,}000}{30 \text{ years}} = \$3{,}253 \text{ per year of life saved}$$

This was an Example of UnProfessional Modeling

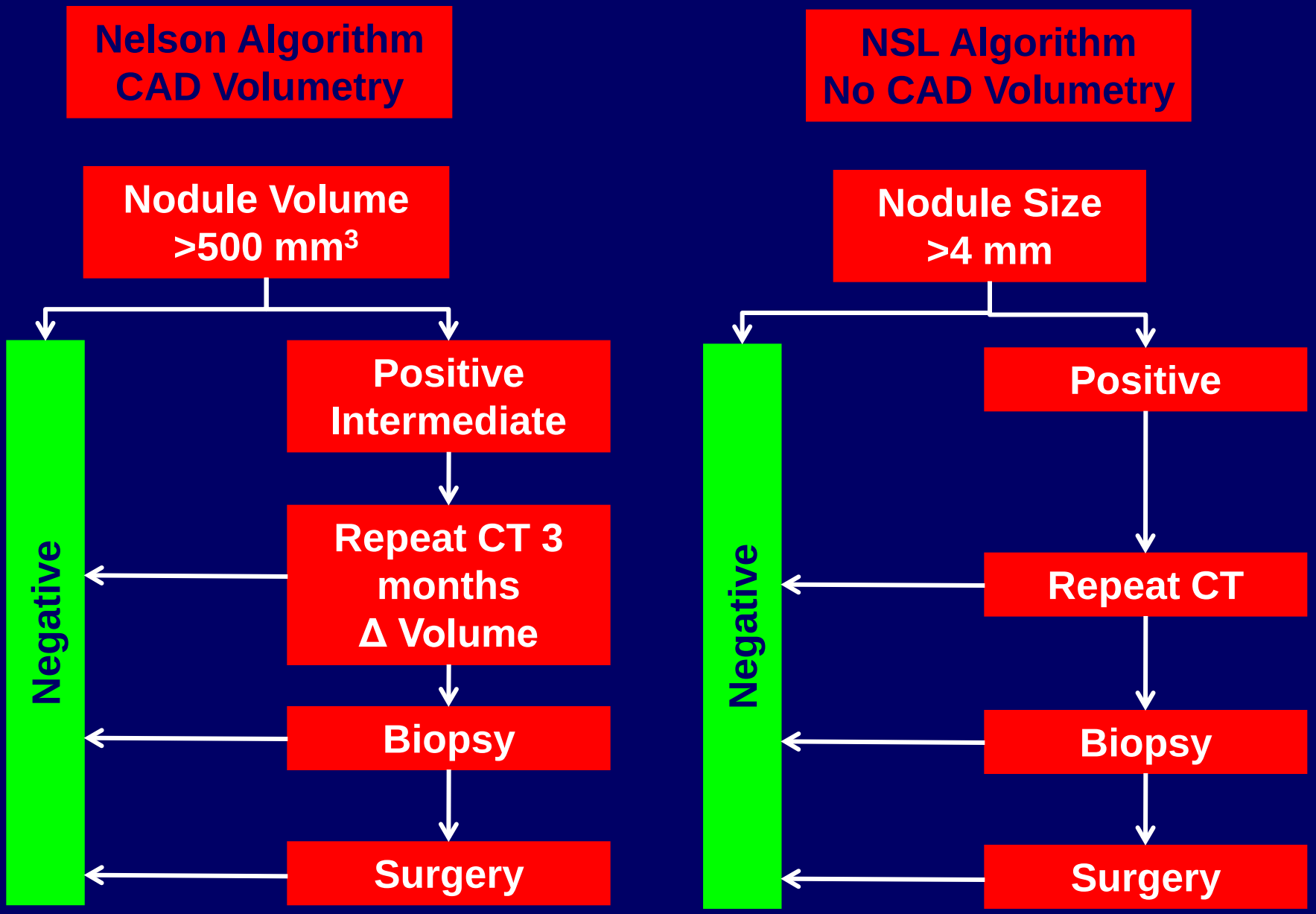
DON'T TRY THIS AT HOME !

Nodule Volumetry

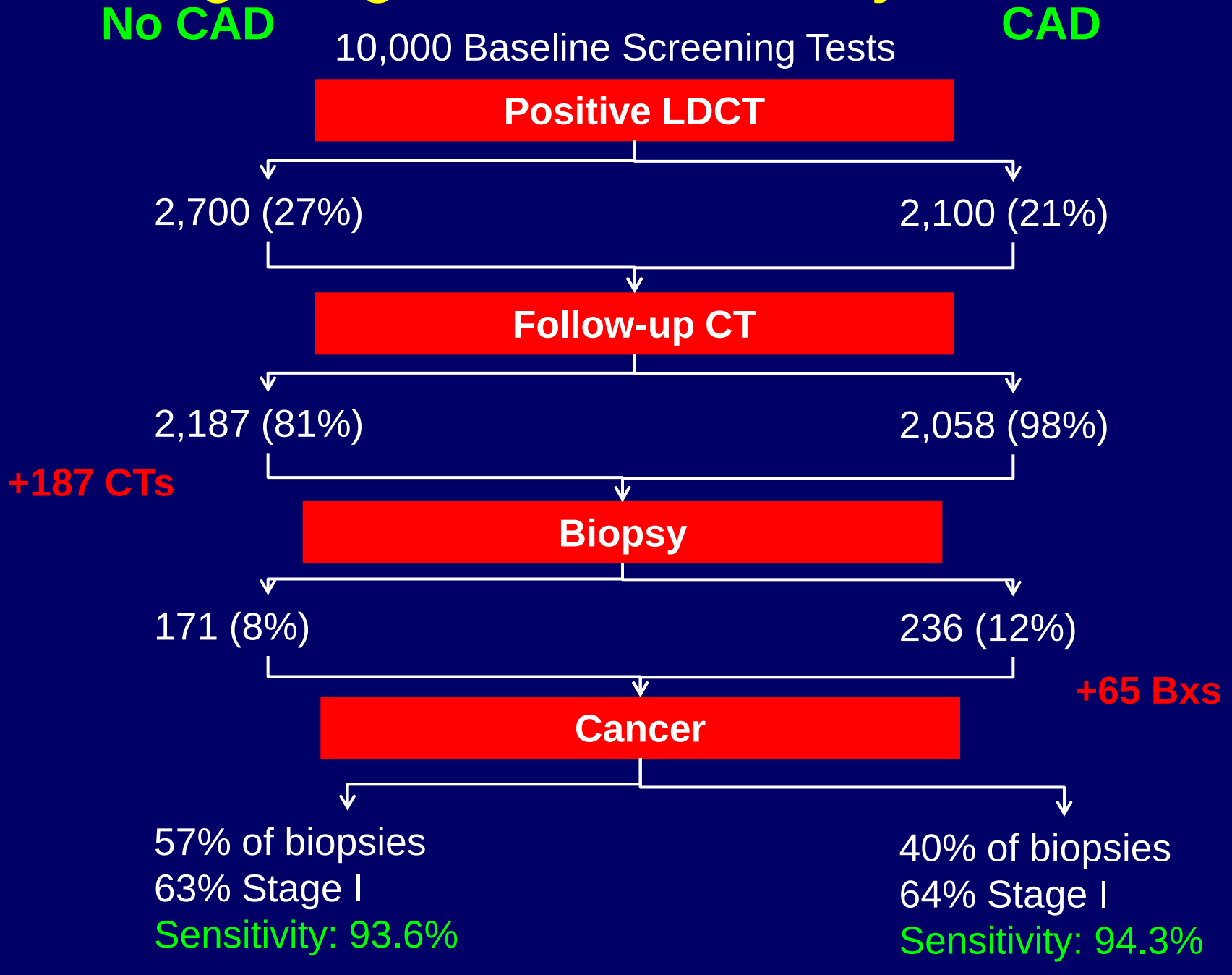




Nodule Volumetry in CT Screening



Integrating Nodule Volumetry with LDCT



Costs of LDCT Screening with Use of Nodule Volumetry

Savings				Additional Costs			
Event	**Number**	**Cost per event**	**Total Savings**	**Event**	**Number**	**Cost per event**	**Total Added Costs**
Follow-up CTs	129	$200	$2,580	Biopsies	65	$1,000	$65,000
		Total	**$25,800**			**Total**	**$65,000**

- Assuming similar sensitivity there is no difference in LE with CAD
- NO CAD strategy is dominant

Costs of LDCT Screening with Use of Nodule Volumetry

Savings				Additional Costs			
Event	**Number**	**Cost per event**	**Total Savings**	**Event**	**Number**	**Cost per event**	**Total Added Costs**
Follow-up CTs	129	$200	$2,580	Biopsies	0	$0	$0
		Total	**$25,800**			**Total**	**$0**

- Assuming similar sensitivity there is no difference in LE with CAD
- CAD strategy is dominant

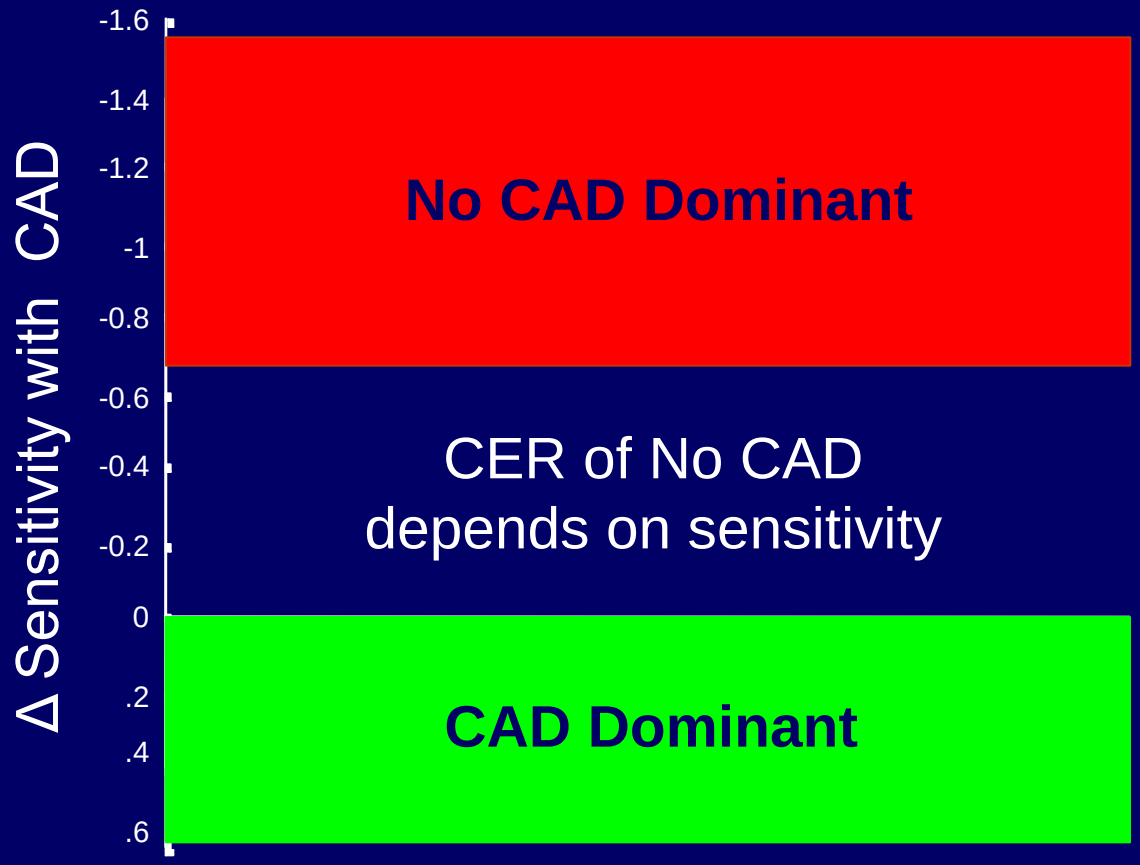
Costs of LDCT Screening with Use of Nodule Volumetry

- Assume no increased use of biopsy
- Sensitivity ↓ by 2%: 5 missed cancers with CAD

Savings				Additional Costs			
Event	**Number**	**Cost per event**	**Total Savings**	**Event**	**Number**	**Cost per event**	**Total Added Costs**
Follow-up CTs	129	$200	$25,800	Biopsies	0	0	0
				Late vs. early stage	3	$30,000	$90,000
		Total	**$25,800**			**Total**	**$90,000**

- NO CAD strategy is dominant

Preferred Strategy According to Sensitivity of CAD



“That went well”

Other Uses of CAD

- Growth of GGOs
- Morphologic analysis of NCNs or GGOs
- Nodule Matching

Conclusions

- LDCT for lung cancer screening is likely CE
- The CER compares favorable to other cancer screening tests
- CAD may improve identification of nodules and work-up of positive screening CTs
- The CE of CAD for nodule detection likely depends on its sensitivity in relationship with readings by radiologists
- Preferences regarding strategies based on nodule volumetry appear to depend on the sensitivity of CAD and the need for additional biopsies
- Formal CE analyses are needed

Cost-Effectiveness?

"The jury's still out on it's effectiveness, but it is cost-effective and covered by insurance"