Published in final edited form as:

Int J Cardiovasc Imaging. 2016 February ; 32(2): 309–315. doi:10.1007/s10554-015-0758-z.

Costs and clinical outcomes for non-invasive versus invasive diagnostic approaches to patients with suspected in-stent restenosis

James K. Min^{1,2}, James T. Hasegawa³, Susanne F. Machacz³, and Ken O'Day⁴

James K. Min: runone123@gmail.com, jkm2001@med.cornell.edu

¹ Department of Radiology, Weill Cornell Medical College, New York, NY, USA

² Dalio Institute of Cardiovascular Imaging, NewYork-Presbyterian Hospital and the Weill Cornell Medical College, 413 E. 69th Street, Suite 108, New York 10021, NY, USA

³ Abbott Vascular, Santa Clara, CA, USA

⁴ Xcenda, Palm Harbor, FL, USA

Abstract

This study compared costs and clinical outcomes of invasive versus non-invasive diagnostic evaluations for patients with suspected in-stent restenosis (ISR) after percutaneous coronary intervention. We developed a decision model to compare 2 year diagnosis-related costs for patients who presented with suspected ISR and were evaluated by: (1) invasive coronary angiography (ICA); (2) non-invasive stress testing strategy of myocardial perfusion imaging (MPI) with referral to ICA based on MPI; (3) coronary CT angiography-based testing strategy with referral to ICA based on CCTA. Costs were modeled from the payer's perspective using 2014 Medicare rates. 56 % of patients underwent follow-up diagnostic testing over 2 years. Compared to ICA, MPI (98.6 %) and CCTA (98.1 %) exhibited lower rates of correct diagnoses. Non-invasive strategies were associated with reduced referrals to ICA and costs compared to an ICA-based strategy, with diagnostic costs lower for CCTA than MPI. Overall 2-year costs were highest for ICA for both metallic as well as BVS stents (\$1656 and \$1656, respectively) when compared to MPI (\$1444 and \$1411) and CCTA. CCTA costs differed based upon stent size and type, and were highest for metallic stents >3.0 mm followed by metallic stents <3.0 mm, BVS < 3.0 mm and BVS > 3.0 mm (\$1466 vs. \$1242 vs. \$855 vs. \$490, respectively). MPI for suspected ISR results in lower costs and rates of complications than invasive strategies using ICA while maintaining high diagnostic performance. Depending upon stent size and type, CCTA results in lower costs than MPI.

Correspondence to: James K. Min, runone123@gmail.com jkm2001@med.cornell.edu.

Compliance with ethical standards

Conflict of interest Dr. James K. Min serves as a consultant to Abbott Vascular and HeartFlow, Inc.; GE Healthcare; and serves on the medical advisory board of GE Healthcare and Arineta. James T. Hasegawa, Susanne F. Machacz, Ken O'Day declare that they have no conflict of interest.

Keywords

Cost efficiency; Revascularization; Computed tomography; Stents

Introduction

In the United States each year, approximately 954,000 percutaneous coronary interventions (PCI) are performed [1]. While the introduction of bare metal stents (BMS) and drug eluting metallic stents (DES) has dramatically reduced the incidence of restenosis rates over primary angioplasty alone, current generation drug eluting stents (DES) and bare metal stents (BMS) are nevertheless affected by in-stent restenosis (ISR) rates of up to 5 and 30 % within the first year following implantation, respectively [2, 3].

The diagnostic approach to patients with suspected ISR has been difficult [4]. While invasive coronary angiography (ICA) has been considered the “gold standard” test for evaluation of patients with suspected ISR, it is nevertheless costly and carries the risk of complications. Historically, many individuals with suspected ISR have undergone diagnostic evaluation by stress testing—most commonly with myocardial perfusion imaging (MPI) by single photon emission computed tomography (SPECT)—with variable efficacy, and the final determination of stent patency often requires invasive evaluation by coronary angiography (ICA) [5].

In recent years, coronary CT angiography (CCTA) has emerged as a potential non-invasive alternative to ICA, and has demonstrated high diagnostic performance for the detection and exclusion of high-grade anatomic stenosis in native coronary arteries [6–8]. Yet CCTA exhibits a lower diagnostic performance for evaluation of intracoronary stents that is largely ascribed to partial volume and beam hardening CT artifacts [9, 10]. Importantly, diagnostic performance of CCTA is dependent upon stent size and type, with higher accuracy for larger over small diameters, and for polymer-based bioresorbable scaffolds (BVS) over metallic stents.

To date, the downstream costs and clinical outcomes associated with invasive versus non-invasive evaluation of patients with suspected ISR has not been evaluated. We thus developed a contemporary decision analytic model to estimate the efficacy of evaluation of patients with suspected ISR using ICA, MPI or CCTA.

Methods

We assessed the costs of three strategies for diagnostic evaluation of patients with symptomatic angina with suspected ISR after PCI. These strategies were as follows: (a) an invasive strategy of direct referral to ICA for all patients; (b) a stress MPI strategy of SPECT, with selective referral to ICA after abnormal or equivocal SPECT; (c) a CCTA-based strategy, with selective referral to ICA after abnormal or equivocal CCTA (Fig. 1). Costs were assigned from the perspective of the healthcare payer.

Decision analytic model

We developed a decision analytic model over a 2-year time horizon to evaluate diagnostic work-up strategies, in accordance to the expected length of the episode of care. Test sensitivity, specificity, rates of equivocal test results, and disease prevalence were used to classify patients undergoing ICA, MPI and CCTA as patients with true-positive, false-positive, true-negative, false-negative or equivocal findings for significant ISR. All patients with positive or equivocal findings by CCTA were assumed to be referred to ICA, and ICA was assumed to have perfect sensitivity and specificity.

To compare degrees of abnormality by ICA, MPI and CCTA, we considered two categories relating to the extent and severity of abnormality by each method. For ICA and CCTA, an abnormal test requiring potential intervention was defined as 50 % of greater stenosis in the PCI-related artery. For MPI, any stress-induced perfusion defect was considered to be abnormal and was classified as requiring potentially actionable intervention.

To account for the differential diagnostic performance of CCTA for different stent size and type, we further stratified individuals by stent size and type, with (a) stent size as ≥ 3.0 versus <3.0 mm, and (b) stent type as metallic stent versus BVS (Fig. 2). Metallic stents included both BMS and DES and were allocated in accordance with reported practice patterns. For the diagnostic performance of CCTA, patients with suspected ISR with metallic stents (BMS or DES) underwent evaluation by ICA for stents <3.0 mm and CCTA for stents ≥ 3.0 mm (in direct accordance with current American College of Cardiology Appropriate Use Criteria) [11]. Further, given the radio radiolucency of BVS but not metallic stents, all patients with suspected ISR who underwent PCI with BVS were evaluated by CCTA, irrespective of stent size [12]. Patients with negative MPI or CCTA were assumed to experience persistent angina symptoms and underwent ICA after continued presentation.

Patient population

The modeled patient population included 1000 patients who underwent stent implantation for any reason, with approximately half of patients receiving <3 vs. ≥ 3.0 mm stents, in keeping with current clinical practice [13–15]. For metallic stents, the prevalence of use of DES and BMS was 74 and 26 %, respectively [16].

Clinical presentation and disease prevalence

Rates of symptomatic angina with suspected ISR over the first year was estimated to be 28 %, while actual rates of ISR was 6.6 % for BMS and 3.0 % for DES and BVS [2, 3]. Restenosis rates for BVS were assumed to be equivalent to those of DES.

Test performance characteristics and risks of diagnostic testing

As the reference standard, ICA sensitivity and specificity was assumed to be 100 %. In contrast, the sensitivity and specificity of MPI was 87.0 and 87.0 %, with 16.6 % of studies considered equivocal [17]. CCTA sensitivity, specificity and equivocal rates for ISR for metallic stents was 50.2, 80.7 and 48.0 %, respectively, for metallic stents <3.0 mm; and 100.0, 48.5 and 46.0 %, respectively for metallic stents ≥ 3.0 mm. CCTA sensitivity,

specificity and equivocal rates for BVS was assumed to be comparable to native coronary arteries at 70.0, 70.0 and 5.0 %, respectively for stents <3.0 mm; and 90.0, 96.0 and 5.0 %, respectively, for stents ≥ 3.0 mm [18]. Test complications were 0 % for both MPI and CCTA, and 2.0 % of the time for ICA [19, 20].

Costs

Test performance costs were based upon current United States Medicare reimbursement rates, and were higher for ICA (\$2854) than for MPI (\$1222) and CCTA (\$341) [21]. Costs of test complications for ICA were estimated to be \$11,853 for the US, based upon previously published data and adjusted to 2013 US dollars using the Medical Care Component of the Consumer Price Index (CPI) [19, 22]. Costs were discounted at 3.0 % annually over the 2-year model time horizon.

Model outputs

Model outputs included the proportion of patients with suspected ISR (56 %) who were evaluated with ICA, MPI and CCTA, stress test, as well as overall diagnostic performance and total diagnostic costs per stented patient.

Results

The 2-year test rates and test outcomes per 1000 stented patients are listed in Table 1 by diagnostic strategy. In the ICA group, 100 % of patients with suspected ISR underwent ICA. In the MPI group, 45–48 % of evaluated patients underwent ICA regardless of stent type. In the CCTA group, 64 and 78 % of patients underwent ICA for metallic stents of <3.0 and ≥ 3.0 mm diameter, respectively; while 41 and 19 % of patients, respectively, underwent ICA for BVS stents <3.0 and ≥ 3.0 mm.

Correct diagnosis and downstream complication rates

Correct diagnoses were highest in the ICA cohort, with similar diagnostic performance of MPI and CCTA that ranged between 95 and 99 %. Test complications were lowest for MPI patients (0.9 %), followed by CCTA (1.0 %) and then ICA (2.0 %). Test complications were lower for CCTA when BVS was used.

Overall, costs per stented patient were highest for an ICA strategy, followed by an MPI and then CCTA strategy (Fig. 2). While 2-year ICA and MPI-based evaluation costs were generally similar based upon metallic versus BVS stent type, CCTA-based evaluation costs between \$500 and \$1500 depending on stent type and size.

Sensitivity analysis

We performed one-way sensitivity analyses varying key model parameters by 10 %. Key parameters included sensitivity, specificity and equivocal rates of test performance; stent-based angina rates and test costs (Table 2). In this sensitivity analysis, costs were highest for ICA, followed by MPI and then CCTA. Additionally, the model appeared most sensitive to diagnostic test specificity and symptomatic angina rates.

Discussion

We developed a decision analytic model to compare costs and outcomes of invasive and non-invasive diagnostic strategies for evaluation of patients presenting with suspected ISR following PCI. We examined three algorithms that included ICA-, MPI- and CCTA-based strategies, and further examined the economic efficiencies when considering stent size and type. In this study, we observed high diagnostic performance of non-invasive strategies (ranging from 96 to 100 % correct diagnoses), with significant cost savings with both an MPI- and CCTA-based strategy. These non-invasive strategies resulted in a lower rate of referral to ICA than an invasive strategy with an associated reduction in the rate of complications. Importantly, the diagnostic performance and rates of complications of the CCTA-based approach was dependent upon both stent type, with overall costs lower for BVS stents. These findings remained consistent across the range of parameter values for test performance characteristics, angina rates, and test costs assessed in the sensitivity analyses.

To our knowledge, this study is the first decision analytic model to directly compare invasive versus non-invasive diagnostic strategies for evaluation of patients with suspected ISR, and suggests initial performance of MPI or CCTA as a potentially beneficial approach to evaluation of these patients. Given that ISR is an insidious rather than acute condition, a non-invasive evaluation is perhaps expected to be safer than an invasive evaluation for all-comers, and the findings of the present study support such a concept [23]. Although the cost savings appeared superior for a CCTA-based strategy over an MPI-based strategy, the CCTA-based strategy was associated with a small increase in rates of complications (1.0 vs. 0.9 %). Coupled with the high diagnostic performance of MPI observed in this study, patients with suspected ISR may be evaluated effectively by MPI, which is widely available and commonly practiced in the United States [24–26].

Yet a “one-size-fits-all” strategy appears to be too simplistic when considering non-invasive imaging methods for ISR evaluation, as diagnostic costs, diagnostic performance and rates of complications differed according to stent size and type. We observed significant costs savings when CCTA was employed for evaluation of BVS (whether 3.0 or <3.0 mm) as compared to either CCTA for metallic stents or to MPI. These cost savings were driven by improved diagnostic test performance of CCTA in BVS patients due to enhanced visualization of the coronary lumen with non-metallic scaffolds. In this regard, CCTA for individuals with suspected ISR after BVS implantation may be more advantageous as an initial diagnostic strategy, and future prospective studies confirming this hypothesis now appear warranted [27, 28].

Notably, we constructed the present decision analysis assuming uniformity of angina rates amongst individuals undergoing PCI by any stent platform in order to isolate the costs and complications associated with invasive versus non-invasive diagnostic strategies. It is possible that angina rates following PCI are different for bare metal versus drug eluting stents, and this study did not address these potential differences. Further, recent multicenter trial data suggest a lower rate of angina after PCI with BVS and thus the present analysis may have underestimated the efficacy of CCTA for evaluation of suspected ISR in BVS patients [29].

Each of the aforementioned study findings has important clinical implications. Given that multiple non-invasive tests are available to the physician as well as the reluctance of many patients to undergo repeat invasive diagnostic procedures, safe and economically sound non-invasive pathways that provide high diagnostic accuracy may support the need for standardized non-invasive clinical algorithms for patients with suspected ISR after PCI. These findings have important consequences, and may inform the design of future PCI trials that aim to reduce the economic burden of ISR evaluation to the healthcare system.

This study is not without limitations. While all model inputs were obtained from contemporary prospective multicenter studies, they are nevertheless prone to potential publication biases that can affect all decision analytic models; future validation studies should be performed. Further, while we tested 3 distinct strategies that compared an invasive reference “ground truth” to non-invasive imaging by physiologic and anatomic methods, we did not assess the totality of available non-invasive methods including stress echocardiography, exercise treadmill testing, cardiac magnetic resonance imaging and positron emission tomography. For this analysis, we focused on CCTA and MPI as exemplars of the most commonly utilized anatomic and physiologic non-invasive imaging tests, respectively, for suspected ISR. Construction of a model incorporating all other available modalities is possible but will tender more information at the expense of precision and accuracy. Finally, while we examined the clinical outcomes related to test complications, we did not examine clinical outcomes related to incident myocardial infarction or cardiac-related death due to stent thrombosis. Because stent thrombosis rates are unknown for BVS, inclusion of this rare event (~0.1 % for BMS), would discriminatorily skew results in a favorable fashion towards any given diagnostic modality more effective at evaluation of BMS. Instead, this study sought to examine the economic effects of different testing strategies for ISR evaluation. Ongoing multicenter trials may help elucidate the potential differences in stent type and how these differences may have a direct effect on the cost efficiency of diagnostic testing for suspected ISR (NCT02173379).

Conclusion

On the basis of different diagnostic pathways, patients with suspected ISR incur lower costs and rates of complications when evaluated by a non-invasive versus invasive strategy. While CCTA results in overall lower costs than MPI, CCTA strategy-based costs are dependent upon stent size and type.

Acknowledgments

Funding sources This study was funded by Abbott Vascular. This study was also funded, in part, by the Dalio Institute of Cardiovascular Imaging, the Michael J. Wolk Foundation and a grant from the National Institutes of Health (NIH R01HL118019).

References

1. Go AS, Mozaffarian D, Roger VL, et al. Heart disease and stroke statistics—2014 update: a report from the American Heart Association. *Circulation*. 2014; 129(3):e28–e292. [PubMed: 24352519]
2. Cohen DJ, Van Hout B, Serruys PW, et al. Quality of life after PCI with drug-eluting stents or coronary-artery bypass surgery. *N Engl J Med*. 2011; 364(11):1016–1026. [PubMed: 21410370]

3. Stenestrand U, James SK, Lindback J, et al. Safety and efficacy of drug-eluting vs. bare metal stents in patients with diabetes mellitus: long-term follow-up in the Swedish Coronary Angiography and Angioplasty Registry (SCAAR). *Eur Heart J*. 2010; 31(2):177–186. [PubMed: 19903684]
4. Alfonso F, Byrne RA, Rivero F, Kastrati A. Current treatment of in-stent restenosis. *J Am Coll Cardiol*. 2014; 63(24):2659–2673. [PubMed: 24632282]
5. de Graaf FR, Schuijf JD. Evaluation of stents and grafts. *EuroIntervention*. 2010; 6(Suppl G):G48–G56. [PubMed: 20542828]
6. Budoff MJ, Dowe D, Jollis JG, et al. Diagnostic performance of 64-multidetector row coronary computed tomographic angiography for evaluation of coronary artery stenosis in individuals without known coronary artery disease: results from the prospective multicenter ACCURACY (Assessment by Coronary Computed Tomographic Angiography of Individuals Undergoing Invasive Coronary Angiography) trial. *J Am Coll Cardiol*. 2008; 52(21):1724–1732. [PubMed: 19007693]
7. Meijboom WB, Meijs MF, Schuijf JD, et al. Diagnostic accuracy of 64-slice computed tomography coronary angiography: a prospective, multicenter, multivendor study. *J Am Coll Cardiol*. 2008; 52(25):2135–2144. [PubMed: 19095130]
8. Miller JM, Rochitte CE, Dewey M, et al. Diagnostic performance of coronary angiography by 64-row CT. *N Engl J Med*. 2008; 359(22):2324–2336. [PubMed: 19038879]
9. Cademartiri F, Maffie E, Palumbo A, et al. CT coronary angiography for the follow-up of coronary stent. *Acta Biomed*. 2010; 81(2):87–93. [PubMed: 21305872]
10. Andreini D, Pontone G, Mushtaq S, Pepi M, Bartorelli AL. Multidetector computed tomography coronary angiography for the assessment of coronary in-stent restenosis. *Am J Cardiol*. 2010; 105(5):645–655. [PubMed: 20185011]
11. Ronan G, Wolk MJ, Bailey SR, et al. ACCF/AHA/ASE/ ASNC/HFSA/HRS/SCAI/SCCT/SCMR/STS 2013 multimodality appropriate use criteria for the detection and risk assessment of stable ischemic heart disease: a report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Failure Society of America, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and Society of Thoracic Surgeons. *J Nucl Cardiol*. 2014; 21(1):192–220. [PubMed: 24374980]
12. Nieman K, Serruys PW, Onuma Y, et al. Multislice computed tomography angiography for noninvasive assessment of the 18-month performance of a novel radiolucent bioresorbable vascular scaffolding device: the ABSORB trial (a clinical evaluation of the bioabsorbable everolimus eluting coronary stent system in the treatment of patients with de novo native coronary artery lesions). *J Am Coll Cardiol*. 2013; 62(19):1813–1814. [PubMed: 23933536]
13. Wykrzykowska JJ, Arbab-Zadeh A, Godoy G, et al. Assessment of in-stent restenosis using 64-MDCT: analysis of the CORE-64 Multicenter International Trial. *Am J Roentgenol*. 2010; 194(1):85–92. [PubMed: 20028909]
14. Nakamura K, Funabashi N, Uehara M, et al. Impairment factors for evaluating the patency of drug-eluting stents and bare metal stents in coronary arteries by 64-slice computed tomography versus conventional coronary angiography. *Int J Cardiol*. 2008; 130(3):349–356. [PubMed: 18180050]
15. Sheth T, Dodd JD, Hoffmann U, et al. Coronary stent accessibility by 64 slice multi-detector computed tomography. *Catheter Cardiovasc Interv*. 2007; 69(7):933–938. [PubMed: 17421013]
16. Groeneveld PW. How drug-eluting stents illustrate our health system's flawed relationship with technology: comment on "use of drug-eluting stents as a function of predicted benefit". *Arch Intern Med*. 2012; 172(15):1152–1153. [PubMed: 22777509]
17. Chinnaiyan KM, Raff GL, Goraya T, et al. Coronary computed tomography angiography after stress testing: results from a multicenter, statewide registry, ACIC (Advanced Cardiovascular Imaging Consortium). *J Am Coll Cardiol*. 2012; 59(7):688–695. [PubMed: 22322086]
18. Pontone G, Andreini D, Bartorelli AL, et al. Radiation dose and diagnostic accuracy of multidetector computed tomography for the detection of significant coronary artery stenoses: a metaanalysis. *Int J Cardiol*. 2012; 160(3):155–164. [PubMed: 21978473]

19. Moscucci M. Frequency and costs of ischemic and bleeding complications after percutaneous coronary interventions: rationale for new antithrombotic agents. *J Invasive Cardiol.* 2002; 14(Suppl B):55B–64B.
20. Bell GW, Edwardes M, Dunning AM, et al. Periprocedural safety of 64-detector row coronary computed tomographic angiography: results from the prospective multicenter ACCURACY trial. *J Cardiovasc Comput Tomogr.* 2010; 4(6):375–380. [PubMed: 21030334]
21. Hospital Outpatient Prospective Payment System. Centers for Medicare & Medicaid Services. website. <https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/HospitalOutpatientPPS/Hospital-Outpatient-Regulations-and-Notices-Items/CMS-1589-FC.html?DLPage=1&DLSort=2&DLSortDir=descending>. Accessed Aug 2014
22. Consumer Price Index. Bureau of Labor Statistics website. 2014. <http://data.bls.gov/cgi-bin/surveymost?cu>
23. Schiele TM. Current understanding of coronary in-stent restenosis. Pathophysiology, clinical presentation, diagnostic work-up, and management. *Z Kardiol.* 2005; 94(11):772–790. [PubMed: 16258781]
24. Berman DS, Hachamovitch R, Shaw LJ, et al. Roles of nuclear cardiology, cardiac computed tomography, and cardiac magnetic resonance: assessment of patients with suspected coronary artery disease. *J Nucl Med.* 2006; 47(1):74–82. [PubMed: 16391190]
25. Shaw LJ, Min JK, Hachamovitch R, et al. Cardiovascular imaging research at the crossroads. *JACC Cardiovasc Imaging.* 2010; 3(3):316–324. [PubMed: 20223430]
26. Berman DS, Abidov A, Hachamovitch R, et al. Comparative roles of cardiac CT and nuclear cardiology in assessment of the patient with suspected coronary artery disease. *J Invasive Cardiol.* 2009; 21(7):352–358. [PubMed: 19571348]
27. Nallu K, Yang DC, Swaminathan RV, Kim LK, Feldman D. Innovations in drug-eluting stents. *Panminerva Med.* 2013; 55(4):345–352. [PubMed: 24434343]
28. Balla S, Aggarwal K, Nistala R. Bioabsorbable coronary stents—are these the next big thing in coronary angioplasty? *Recent Pat Cardiovasc Drug Discov.* 2010; 5(2):86–90. [PubMed: 20158469]
29. Serruys PW, Chevalier B, Dudek D, et al. A bioresorbable everolimus-eluting scaffold versus a metallic everolimus-eluting stent for ischaemic heart disease caused by de-novo native coronary artery lesions (ABSORB II): an interim 1-year analysis of clinical and procedural secondary outcomes from a randomised controlled trial. *Lancet.* 2015; 385(9962):43–54. [PubMed: 25230593]

Fig. 1.
Evaluation pathway of individuals with angina and/or suspected in-stent restenosis following percutaneous coronary intervention

Fig. 2.
Two-year diagnostic costs per stented patient

Table 1

Two-year tests and test outcomes per 1000 stented patients

Strategy	ICA		MPI		CCTA		BVS	
	Metallic		Metallic		Metallic		<3.0 mm	
	All	All	All	All	<3.0 mm	3.0 mm	<3.0 mm	3.0 mm
Stent type								
Stent size								
Tested patients	560 (56.0 %)	560 (56.0 %)	560 (56.0 %)	560 (56.0 %)	560 (56.0 %)	560 (56.0 %)	560 (56.0 %)	560 (56.0 %)
MPI tests	0 (0.0 %)	0 (0.0 %)	560 (100.0 %)	560 (100.0 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)
CCTA tests	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	560 (100.0 %)	560 (100.0 %)	560 (100.0 %)	560 (100.0 %)
ICA tests	560 (100.0 %)	560 (100.0 %)	267 (47.7 %)	256 (45.6 %)	358 (63.9 %)	434 (77.5 %)	228 (40.6 %)	104 (18.6 %)
Tests complications	11 (2.0 %)	11 (2.0 %)	5 (1.0 %)	5 (0.9 %)	7 (1.3 %)	9 (1.5 %)	5 (0.8 %)	2 (0.4 %)
Correct diagnosis	560 (100.0 %)	560 (100.0 %)	551 (98.5 %)	540 (98.8 %)	540 (96.4 %)	560 (100.0 %)	543 (96.9 %)	554 (99.0 %)

ICA invasive coronary angiography, MPI myocardial perfusion imaging, CCTA coronary CT angiography, BVS bioabsorbable vascular scaffold

Table 2

Sensitivity analysis of model parameters on 2-year diagnostic costs

Strategy	ICA		MPI		CCTA			
	Metallic	BVS	Metallic	BVS	Metallic		BVS	
					<3.0 mm	3.0 mm	<3.0 mm	3.0 mm
Sensitivity	N/A	N/A	87.0 %	87.0 %	50.2 %	100.0 %	70.0 %	70.0 %
			\$1444 (78.3 %)	\$1411 (78.3 %)	\$1242 (45.2 %)	\$1466 (90.0 %)	\$855 (63.0 %)	\$490 (81.0 %)
			\$1444 (95.7 %)	\$1411 (95.7 %)	\$1242 (55.2 %)	\$1466 (100.0 %)	\$855 (77.0 %)	\$490 (99.0 %)
Specificity	N/A	N/A	73.0 %	73.0 %	80.7 %	48.5 %	70.0 %	70.0 %
			\$1531 (65.7 %)	\$1501 (65.7 %)	\$1301 (72.6 %)	\$1503 (43.7 %)	\$954 (63.0 %)	\$625 (86.4 %)
			\$1358 (80.3 %)	\$1321 (80.3 %)	\$1182 (88.8 %)	\$1429 (53.4 %)	\$757 (77.0 %)	\$434 (100.0 %)
Equivocal	N/A	N/A	16.6 %	\$1393	\$1186	\$1434	\$850	\$483
			\$1427 (14.9 %)	16.6 % (14.9 %)	48.0 % (43.2 %)	46.0 % (41.4 %)	5.0 % (4.5 %)	5.0 % (4.5 %)
			\$1462 (18.3 %)	\$1428 (18.3 %)	\$1297 (52.8 %)	\$1498 (50.6 %)	\$861 (5.5 %)	\$497 (5.5 %)
BMS angina rate	28.0 %	28.0 %	28.0 %	28.0 %	28.0 %	28.0 %	28.0 %	28.0 %
	\$1613 (25.2 %)	\$1656 (25.2 %)	\$1410 (25.2 %)	\$1411 (25.2 %)	\$1212 (25.2 %)	\$1430 (25.2 %)	\$855 (25.2 %)	\$490 (25.2 %)
	\$1699 (30.8 %)	\$1656 (30.8 %)	\$1478 (30.8 %)	\$1411 (30.8 %)	\$1271 (30.8 %)	\$1503 (30.8 %)	\$855 (30.8 %)	\$490 (30.8 %)
DES/BVS angina rate	28.0 %	28.0 %	28.0 %	28.0 %	28.0 %	28.0 %	28.0 %	28.0 %
	\$1534 (25.2 %)	\$1490 (25.2 %)	\$1348 (25.2 %)	\$1280 (25.2 %)	\$1157 (25.2 %)	\$1362 (25.2 %)	\$782 (25.2 %)	\$457 (25.2 %)
	\$1779 (30.8 %)	\$1822 (30.8 %)	\$1041 (30.8 %)	\$1541 (30.8 %)	\$1326 (30.8 %)	\$1570 (30.8 %)	\$929 (30.8 %)	\$523 (30.8 %)
Test cost	\$2854	\$2854	\$1222	\$1222	\$341	\$341	\$341	\$341
	\$1503 (\$2569)	\$1503 (\$2569)	\$1839 (\$1100)	\$1824 (\$1100)	\$1223 (\$307)	\$1448 (\$307)	\$837 (\$307)	\$472 (\$307)
	\$1809 (\$3139)	\$1809 (\$3139)	\$1970 (\$1344)	\$1955 (\$1344)	\$1260 (\$375)	\$1484 (\$375)	\$874 (\$375)	\$509 (\$375)

Values of model parameters are shown in parentheses. Baseline values of model parameters are at the top of each row, low and high parameter values are shown in parentheses. Test sensitivity does not impact the results, as all false negative patients were assumed to have persistent angina symptoms and would undergo a follow-up ICA

ICA invasive coronary angiography, MPI myocardial perfusion imaging, CCTA coronary CT angiography, BVS bioresorbable vascular scaffold, BMS bare metal stent, DES drug eluting stent