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ORIGINAL ARTICLE

Impact of Medicare's Payment Policy on Mediastinitis Following Coronary Artery Bypass Graft Surgery in US Hospitals

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BACKGROUND. The Centers for Medicare and Medicaid Services (CMS) implemented a policy in October 2008 to eliminate additional Medicare payment for mediastinitis following coronary artery bypass graft (CABG) surgery.

OBJECTIVE. To evaluate the impact of this policy on mediastinitis rates, using Medicare claims and National Healthcare Safety Network (NHSN) prospective surveillance data.

METHODS. We used an interrupted time series design to compare mediastinitis rates before and after the policy, adjusted for secular trends. Billing rates came from Medicare inpatient claims following 638,761 CABG procedures in 1,234 US hospitals (January 2006–September 2010). Prospective surveillance rates came from 151 NHSN hospitals in 29 states performing 94,739 CABG procedures (January 2007–September 2010). Logistic regression mixed-effects models estimated trends for mediastinitis rates.

RESULTS. We found a sudden drop in coding for index admission mediastinitis at the time of policy implementation (odds ratio, 0.36 [95% confidence interval (CI), 0.23–0.57]) and a decreasing trend in coding for index admission mediastinitis in the postintervention period compared with the preintervention period (ratio of slopes, 0.83 [95% CI, 0.74–0.95]). However, we saw no impact of the policy on infection rates as measured using NHSN data. Our results were not affected by changes in patient risk over time, heterogeneity in hospital demographics, or timing of hospital participation in NHSN.

CONCLUSIONS. The CMS policy of withholding additional Medicare payment for mediastinitis on the basis of claims-based evidence of infection was associated with changes in coding for infections but not with changes in actual infection rates during the first 2 years after policy implementation.

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In 2008, the Centers for Medicare and Medicaid Services (CMS) implemented a Deficit Reduction Act provision with changes to the Hospital Inpatient Prospective Payment System (IPPS), ceasing additional payment for hospital-acquired conditions (HACs) that were deemed reasonably preventable.¹ CMS used billing codes to identify HACs,² seeking to encourage hospitals to improve outcomes by removing the counterproductive incentive of reimbursing more for patients who develop complications.³

While recent work showed no impact on central catheter-associated bloodstream infection and catheter-associated urinary tract infection,^{4,5} the impact of the policy has not been evaluated for mediastinitis following coronary artery bypass graft (CABG) surgery. Given higher aggregate hospital costs attributable to surgical site infections, it is possible that pay-

ment reform for mediastinitis may have had a greater impact in terms of reducing infections.^{6,7} Approximately 400,000 patients undergo CABG annually in US hospitals,⁸ with an average mediastinitis rate of 0.6% reported to the Centers for Disease Control and Prevention (CDC).⁹ This infection is associated with higher rates of repeat surgery and intensive care unit admission, longer lengths of stay, increased medical costs (more than \$58,000 per episode of mediastinitis), and higher rates of readmission and mortality.^{1,2,10–12}

We evaluated the impact of the HAC policy on mediastinitis following CABG, comparing billing rates in Medicare claims versus prospective surveillance rates reported to the CDC's National Healthcare Safety Network (NHSN).¹³ We presumed that the NHSN data would provide a closer approximation of true infection rates based on standardized clinical and

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laboratory criteria,¹⁴ while billing data would provide insight into whether hospitals changed their billing practices as a response to the policy.

METHODS

Study Population

To examine billing rates of mediastinitis, we used Medicare Provider and Analysis Review (MedPAR) inpatient claims data from January 1, 2006, through December 31, 2010. We included data from acute care, nonfederal US hospitals, excluding critical access hospitals, long-term care hospitals, Maryland waiver hospitals, cancer hospitals, and children's inpatient facilities not subject to the IPPS rule.¹

Separately, we obtained data reported to NHSN from hospitals participating in the Preventing Avoidable Infectious Complications by Adjusting Payment (PAICAP) study.¹⁶ This study recruited acute care, nonfederal US hospitals subject to the IPPS rule that were reporting on mediastinitis following CABG prior to October 1, 2008, when the HAC policy went into effect. These hospitals provided data prospectively collected by hospital staff using standardized CDC/NHSN surveillance definitions.¹⁴ We included hospitals that were reporting data between January 1, 2007, and December 31, 2010. We did not analyze NHSN data from 2006, since only 25 of the participating hospitals were reporting mediastinitis data at that time.

We examined the demographics of US hospitals and NHSN hospitals included in our study by linking to the 2009 American Hospital Association Annual Survey Database.¹⁷ The NHSN hospitals were a subset of all US hospitals performing CABG. For the NHSN hospitals, we analyzed data on all patients undergoing CABG, while the MedPAR inpatient claims data included only Medicare patients.

Study Design

We used an interrupted time series design to evaluate the impact of the HAC policy on billing rates of mediastinitis during the index admission (ie, same hospitalization as CABG) and prospective surveillance rates of mediastinitis reported to NHSN.¹⁸ For Medicare payment purposes, the HAC policy identified mediastinitis only during the index admission.

Applying CMS criteria, we calculated billing rates of mediastinitis during the index admission using *International Classification of Diseases, Ninth Revision* (ICD-9) diagnosis code 519.2 not present on admission following ICD-9 procedure code 36.10–36.17 or 36.19.² We included CABG procedures performed through September 30, 2010. Given prior work showing that most surgical site infections occur after discharge, we separately calculated billing rates including coding for mediastinitis during readmission to an acute care hospital within 90 days of the CABG procedure date.¹⁹ This included surveillance for mediastinitis through December 31,

2010. Current CDC/NHSN surveillance definitions limit reporting of mediastinitis out to 90 days following a CABG procedure.¹³

In the prospective surveillance model, we similarly included NHSN data through September 30, 2010. This was done to mirror the billing model, with NHSN rates including postdischarge surveillance.

Statistical Analysis

All analyses were performed in SAS (ver. 9.3; SAS Institute). We used logistic regression mixed-effects models to evaluate the impact of the HAC policy on quarterly mediastinitis rates, accounting for clustering at the hospital level. We aggregated data by quarter to reduce variability. Independent variables included the policy period (before or after October 1, 2008, allowing for a change in intercept at the time of implementation), time (to adjust for secular trends), and an interaction term to determine whether the policy resulted in a change in slope.

For the claims model, we adjusted for patient-level risk factors linked to surgical site infection following CABG: age,^{20,21} gender,^{21,22} diabetes,^{20,22–25} obesity,^{20,22–25} congestive heart failure,²⁶ renal insufficiency,²⁶ and peripheral vascular disease.^{23,25} These comorbidities were identified using software (ver. 3.7) from the Healthcare Cost and Utilization Project on the basis of ICD-9 codes previously reported by Elixhauser et al.^{27,28}

For the prospective surveillance model, we adjusted for the NHSN risk index, which was reported for all procedures. The NHSN risk index is a composite score incorporating data on a patient's preoperative health status, duration of operation, and any wound contamination at the time of surgery; this score is used to predict the risk of surgical site infection following an operation.²⁹ The NHSN data set did not include the covariates selected for risk adjustment in the claims model.

To assess the completeness of case capture using coding for mediastinitis during the index admission, we evaluated the proportion of mediastinitis cases coded during the index admission or during readmission to an acute care hospital within 90 days of the CABG procedure date. A χ^2 test was used to compare this proportion in the 2 study periods. We also quantified the average length of stay in the 2 study periods to help understand any changes in index admission versus postdischarge case capture.

In the claims model and the prospective surveillance model, we evaluated whether our findings were affected by changes in patient risk over time by modeling our outcome without covariates for patient-level risk factors. For the claims model, we also looked at effect modification by (1) type of ownership (for-profit vs not-for-profit vs public) and (2) percentage of Medicare patients analyzed by quartile. This was done to evaluate whether certain hospitals responded differently to the HAC policy in terms of billing for mediastinitis.

Finally, for the prospective surveillance model, we performed a sensitivity analysis including only hospitals reporting at both the beginning of the study (2007 quarter 1) and the end of the study (2010 quarter 3). This was done to address concerns that if hospitals with higher-risk patients joined later in the study period, they might mask a true decline in mediastinitis rates.

RESULTS

Study Population

There were 1,234 acute care, nonfederal US hospitals subject to the IPPS rule that performed CABG procedures on Medicare patients between January 1, 2006, and September 30, 2010. Among the 398 hospitals participating in the PAICAP study between January 1, 2007, and September 30, 2010, 151 hospitals from 29 states reported CABG data to NHSN. Table 1 shows the demographic features of hospitals included in the study. The subset of US hospitals in the NHSN study

group tended to be larger (400 beds or more), not-for-profit, major teaching hospitals. This group also had a higher proportion of hospitals from the northeast portion of the country.

Billing Rates of Mediastinitis during Index Admission

Following 638,761 CABG procedures performed on Medicare patients between January 1, 2006, and September 30, 2010, only 352 patients (0.06%) were coded as having mediastinitis during the index admission. Figure 1 shows a plot of quarterly mediastinitis rates using coding for this event during the index admission. Coding for index admission mediastinitis was increasing during the baseline period (slope, 1.09 [95% confidence interval (CI), 1.01–1.16]). After the start of the HAC policy, there was an immediate drop, with a relative odds of coding for index admission mediastinitis of 0.36, comparing coding in quarter 4 versus quarter 3 2008 (95% CI, 0.23–0.57). Finally, there was a decreasing trend in coding

TABLE 1. Characteristics of US Hospitals and National Healthcare Safety Network (NHSN) Hospitals Performing Coronary Artery Bypass Graft Surgery in Our Study Populations

Characteristic	US hospitals (<i>n</i> = 1,234) ^a	NHSN hospitals (<i>n</i> = 151) ^b
Region		
Midwest	329 (27)	36 (25)
Northeast	159 (13)	70 (48)
South	451 (38)	19 (13)
West	259 (22)	20 (14)
Location		
Metro	1,115 (93)	137 (95)
Micro	78 (7)	8 (6)
Rural	5 (<1)	0 (0)
Bed size		
<100	46 (4)	1 (1)
100–399	757 (63)	71 (49)
≥400	395 (33)	73 (50)
Type of ownership		
For-profit	238 (20)	9 (6)
Not-for-profit	831 (69)	121 (83)
Public	129 (11)	15 (10)
Teaching status		
Graduate	314 (26)	39 (27)
Major	234 (20)	61 (42)
Minor	87 (7)	6 (4)
Nonteaching	563 (47)	39 (27)
Full-time equivalent nurses ^c		
Median	7.0	7.2
Interquartile range	5.8–8.4	6.0–8.5
Medicare admissions, %		
Median	44	42
Interquartile range	38–50	37–48

NOTE. Data are no. (%), unless otherwise indicated.

^a 36 hospitals with missing American Hospital Association (AHA) data.

^b 6 hospitals with missing AHA data.

^c Data are no. of nurses per 1,000 patient-days.

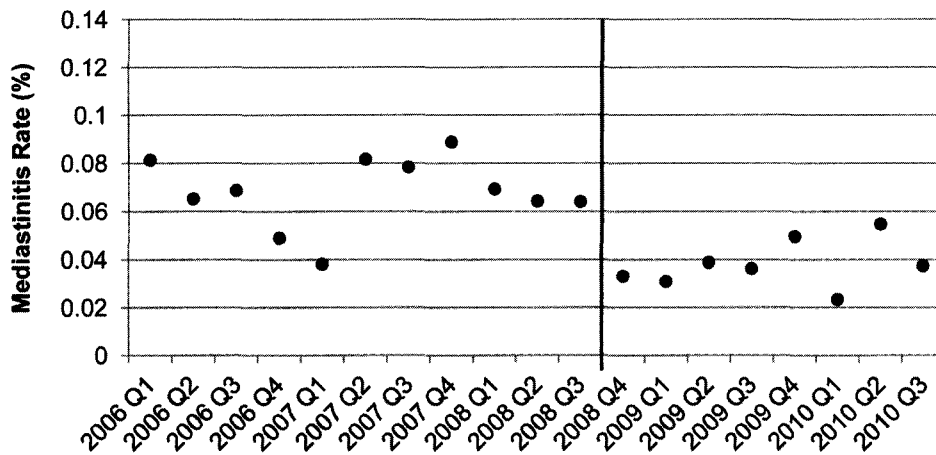


FIGURE 1. Quarterly rates of index admission mediastinitis based on Medicare claims data. Vertical line indicates start date of Centers for Medicare and Medicaid Services hospital-acquired condition policy.

for index admission mediastinitis in the postintervention period compared with the preintervention period (ratio of slopes, 0.83 [95% CI, 0.74–0.95]).

Prospective Surveillance Rates of Mediastinitis

Hospitals participating in the PAICAP study reported 94,739 CABG procedures to NHSN between January 1, 2007, and September 30, 2010, with mediastinitis reported following 372 procedures (0.39%). Figure 2 shows a plot of quarterly mediastinitis rates for these hospitals. The rate of mediastinitis reporting was stable in the baseline period (slope, 1.04 [95% CI, 0.94–1.15]), and there was no immediate drop in reporting following intervention (relative odds for quarter 4 vs quarter 3 2008, 1.04 [95% CI, 0.71–1.51]). There was also no change in reporting trends in the postintervention period compared with the preintervention period (ratio of slopes, 0.92 [95% CI, 0.82–1.04]).

Billing Rates Including Postdischarge Data

Including patients with a mediastinitis code on readmission to an acute care hospital within 90 days of surgery, the number of patients with a code for mediastinitis increased to 1,628 (0.25%). Figure 3 shows quarterly mediastinitis rates based on this extended surveillance window, with index admission mediastinitis rates repeated from Figure 1 for comparison. Prior to the HAC policy, 27% of patients with a mediastinitis code within 90 days of surgery had a billing code for mediastinitis during their index admission. This dropped to 14% in the postintervention period, a significant change ($P < .01$). The average length of stay for the index admission was 10.9 days in the preintervention period and 10.6 days in the postintervention period.

Alternative Analyses

Our main findings for the claims model were the same when not accounting for coded comorbidities. While the increase in the preintervention slope was no longer significant, both the immediate drop and the decreasing trend in coding for index admission mediastinitis in the postintervention period remained significant in the non-risk-adjusted model. Similarly, the findings for the prospective surveillance model were the same with and without risk adjustment for the NHSN risk index. This suggests that our findings were not affected by changes in patient risk over time. Additionally, in evaluating coding for index admission mediastinitis, we did not observe a differential response to the HAC policy in terms of different slopes over time by type of ownership or by percentage of Medicare patients analyzed by quartile ($P > .05$ for all interactions). Finally, in the prospective surveillance model, our findings were the same when limited to PAICAP hospitals that consistently reported surgical site infection results during the entire study period, suggesting that the inclusion of hospitals joining later in the study period did not affect our finding that the HAC policy had no impact on the rate of infections reported.

DISCUSSION

The CMS policy of withholding additional Medicare payment for mediastinitis following CABG appears to have been associated with a sudden drop in coding for mediastinitis at the time of policy implementation and a decreasing trend in coding in the postintervention period. There was no discernible impact, however, on surveillance infection rates within the first 2 years of policy implementation. These findings suggest that while hospitals changed coding practice,

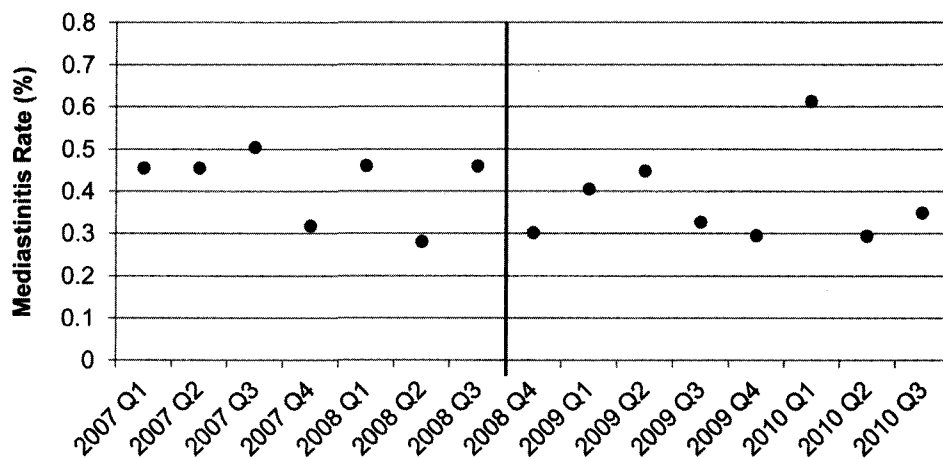


FIGURE 2. Quarterly rates of mediastinitis based on prospective National Healthcare Safety Network surveillance. Vertical line indicates start date of Centers for Medicare and Medicaid Services hospital-acquired condition policy.

clinical outcomes did not significantly change in the time period studied. In interpreting these results, it is important to note that most CMS claims for mediastinitis following CABG were submitted during readmissions rather than during the index hospitalization that was subject to the new policy. This was true even before the policy was implemented, but there was a significant decrease in the percentage of total mediastinitis cases identified by claims during the index admission compared with readmission following implementation of the HAC policy.

These findings highlight the importance of choosing the right metric and understanding its intended purpose. Billing codes can be used to target review of patient records for surgical site infections following CABG, but prior approaches have typically relied on multiple codes to account for coding variation, with tracking over a longer period to capture post-discharge events.³⁰⁻³² While these broader approaches have been successful for auditing surveillance activity,³²⁻³⁴ the goals are different when using codes to determine payment. It is important that the codes selected for a payment policy have a high specificity, meaning that they are rarely used except for the targeted outcome. The challenge with such an approach is that billing practices vary substantially across hospitals, making it difficult for the policy to reliably capture adverse events.³⁵ Additionally, in the case of surgical site infections such as mediastinitis, the adverse events often occur after the patient has left the hospital. Thus, policies to address these infections should consider addressing these postdischarge events.

To our knowledge, this is the first study to demonstrate that the CMS HAC policy resulted in changes in coding practice. This work also adds to growing evidence suggesting that the HAC policy has not yet improved trends in the healthcare-associated infections being targeted.^{4,5} This outcome was previously predicted by McNutt et al³⁶ in a discussion about the

likely cost savings for CMS from the HAC policy. In its original form, the 2008 CMS HAC policy was intended to remove the perverse incentive of paying an additional amount for preventable complications occurring during hospitalization. This policy was one of the first national attempts in the United States to utilize financial disincentives as a lever for improving hospital quality of care. While the impact of pay-for-performance policies on outcomes in hospital settings has been mixed,³⁷⁻⁴¹ the HAC policy has definitely increased awareness of healthcare-associated infections among hospital leadership with a greater focus on what is being publicly reported.^{42,43}

In interpreting our findings, we note some limitations. First, our access to patient-level NHSN data was limited to hospitals participating in the PAICAP study. We therefore may have insufficient power to detect a change in the NHSN data, although the estimates from our models were all close to the null value, suggesting no change. Second, the hospitals included in the prospective surveillance model were a subset of the hospitals included in the billing model. In addition, we analyzed data on all patients undergoing CABG in the prospective surveillance model, while the billing model included data from only Medicare patients. We can therefore not directly compare the rates in these 2 groups. Instead, our study compares the impact of the CMS HAC policy in these 2 different data sources—one focused on billing and the other on prospective surveillance for infections. Third, the factors available for risk adjustment differed in the billing and prospective surveillance models. Our results, however, were similar with and without risk adjustment in each model. Fourth, in our billing model of index admission mediastinitis, it is possible that the increasing slope in the baseline period may have been influenced by outlier rates of coding for index admission mediastinitis in 2006 quarter 4 and 2007 quarter 1, but the drop in coding for this event following the HAC policy was sustained through the end of the study period in

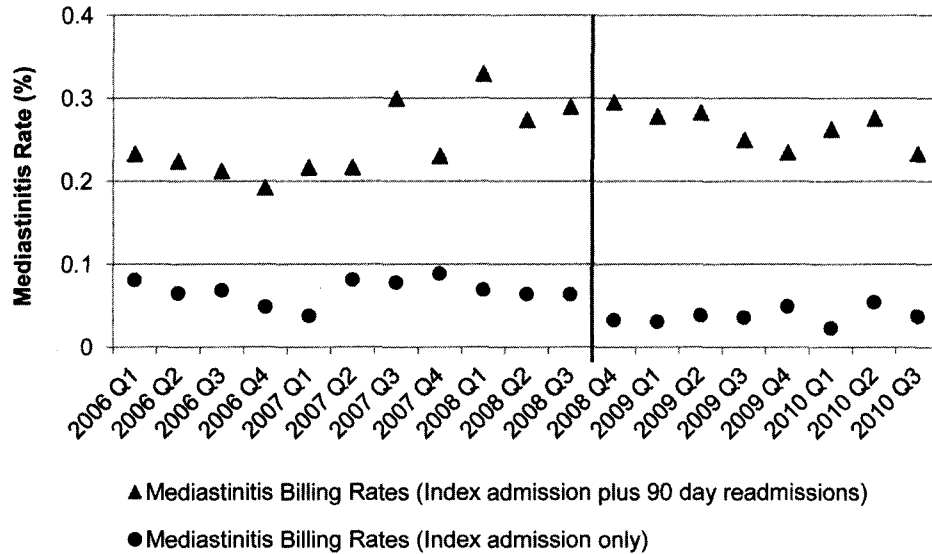


FIGURE 3. Quarterly rates of mediastinitis during the index admission and within 90 days of surgery based on Medicare claims data. Vertical line indicates start date of Centers for Medicare and Medicaid Services hospital-acquired condition policy.

2010 quarter 3. Finally, it is possible that increases in off-pump or minimally invasive CABG procedures may account for some change in the rates of mediastinitis over time in the claims data, although this is unlikely to explain the sudden drop at the time of policy implementation.

As of this writing, CMS continues to refine their policies, including current requirements that hospitals report data on certain healthcare-associated infections to the CDC’s NHSN, with a plan to use these data in the Hospital Inpatient Value-Based Purchasing Program.⁴⁴⁻⁴⁶ CMS is making this NHSN surveillance data publicly available on the Hospital Compare website.⁴⁷ CMS also recently proposed to use NHSN measures for the healthcare-associated infection domain of the HAC reduction program mandated by the Affordable Care Act. This represents a shift away from claims-based measures for public reporting of healthcare-associated infections.

Overall, we conclude that the CMS HAC policy did not reduce rates of mediastinitis following CABG during the first 2 years after the policy was implemented. This may in part be due to the fact that mediastinitis is a rare outcome that most commonly occurs after a patient has been discharged, while the HAC policy focused on events during the surgical admission. Going forward, policymakers will continue to face many challenges in evaluating the ongoing impact of financial disincentives as CMS moves toward the use of NHSN data. Nonetheless, it remains a worthy goal to minimize patient harm and to continue efforts to align quality and payment in US hospitals.

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