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**PRACTICE
PERSPECTIVES**

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Hospitalization Costs for Endovascular and Surgical Treatment of Unruptured Cerebral Aneurysms in the United States Are Substantially Higher Than Medicare Payments

BACKGROUND AND PURPOSE: Both endovascular and surgical options are available for treatment of unruptured cerebral aneurysms. We conducted a study to determine the costs versus Medicare reimbursement for hospitalization of these patients, which is important information for understanding the economic impact of these patients on hospitals.

MATERIALS AND METHODS: Using the NIS, we identified hospitalizations for clipping and coiling of unruptured cerebral aneurysms from 2001 to 2008 by cross-matching ICD-9 codes for diagnosis of unruptured aneurysm with procedure codes for clipping or coiling of cerebral aneurysms and excluding all patients with subarachnoid hemorrhage and intracerebral hemorrhage. Hospital costs for 2008 were correlated with age, sex, and discharge status and compared with Medicare payments.

RESULTS: Costs of both clipping and coiling have increased from 2001 to 2008. The median 2008 hospital costs were \$23,574 (IQR, \$18,233–\$29,941) for clipping and \$25,734 (IQR, \$17,436–\$35,846) for coiling without complications, which were higher than the average Medicare payment of \$12,599. The median hospital costs were \$36,188 (IQR, \$21,831–\$55,308) for clipping and \$40,502 (IQR, \$24,289–\$50,108) for coiling treatments complicated by major morbidity and \$68,165 (IQR, \$32,972–\$100,211) for clipping and \$56,020 for coiling treatments complicated by mortality, which were higher than the average Medicare payment for patients with major complications and comorbidities of \$22,946. In multivariate analysis, female sex was associated with higher costs for coiling ($P = .02$), and poor discharge status was associated with higher costs for both clipping ($P < .001$) and coiling ($P < .001$).

CONCLUSIONS: Hospitalization costs for patients undergoing clipping and coiling of unruptured cerebral aneurysms are substantially higher than Medicare payments.

ABBREVIATIONS: ICD-CM = *International Classification of Diseases–Clinical Modification*; IQR = interquartile range; MS-DRG 2 = craniotomy and endovascular intracranial procedures without complication; NIS = National Inpatient Sample

The number of patients in the United States who undergo treatment for unruptured aneurysm has increased steadily between 2001 and 2008, largely due to the increased use of endovascular coiling.¹ Given the increase in coiling and clipping of unruptured aneurysms during this time period, it would be interesting to assess the trends in hospitalization costs associated with treatment. Hospitalization costs are important to understand because Medicare payments are not keeping pace with inflation. In this study, we used the NIS data base to assess the recent hospitalization costs associated with clipping and coiling of unruptured cerebral aneurysms.

Materials and Methods

Patient Population

We collected and analyzed data from the NIS hospital discharge data base for 2001–2008, which were acquired from the Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality, Rockville, Maryland. The NIS is a hospital discharge data

base that represents 20% of all inpatient admissions to nonfederal hospitals in the United States (www.hcup-us.ahrq.gov/nisoverview.jsp). All patients included in this study carried a primary diagnosis of unruptured aneurysm (code 437.3 in the ICD-9-CM) and a primary ICD-9-CM procedure code of “clipping of aneurysm” (ICD-9-CM Code 39.51) or of coiling of aneurysm, which included “other repair of aneurysm” (ICD-9-CM Code 39.52), “endovascular repair or occlusion of head and neck vessels,” (ICD-9-CM Code 39.72) and “other endovascular repair (of aneurysm) of other vessels” (ICD-9-CM Code 39.79). We excluded all patients with a diagnosis of “subarachnoid hemorrhage” (ICD-9-CM Code 430) and “intracerebral hemorrhage” (ICD-9-CM Code 431).

We examined the correlation between the following variables and total costs in 2008: age, sex, and discharge status (home/short-term facility, long-term facility, and in-hospital death). Medicare costs are public information (<http://www.cms.hhs.gov>) and were compared with the 2008 hospitalization cost data.

For 2001 to 2008, we calculated median hospital costs for hospitalization for clipping and coiling to evaluate cost trends with time. All costs were converted to their dollar value in 2008.

Statistical Analysis

We used the nonparametric Wilcoxon rank sum test to determine statistical significance. In this study, we present medians and IQRs rather than means and SDs because the data were not normally dis-

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Hospitalization costs in 2008 for clipping and coiling of unruptured intracranial aneurysms

Variable	Clipping			Coiling			P Clipping vs Coiling
	Median Cost (US \$2008)	IQR (US \$2008)	P	Median Cost (US \$2008)	IQR (US \$2008)	P	
All patients	24,123	18,775–31,523	–	26,018	17,544–37,001	–	.04
Sex							
Male	25,236	19,463–35,432	.06	25,954	16,917–38,799	.91	.69
Female	23,724	18,251–31,033		26,018	17,793–36,038		.008
Age (yr)							
<65	24,288	18,237–31,578	.95	26,476	17,865–36,264	.52	.03
≥65	23,568	19,039–31,275		25,121	16,850–37,416		.63
Discharge status							
Home/short-term facility	23,574	18,233–29,941	<.001	25,734	17,436–35,846	<.001	<.001
Long-term facility	36,188	21,831–55,308		40,502	24,289–50,108		.51
Dead	68,165	32,972–100,211		56,020	–		.77

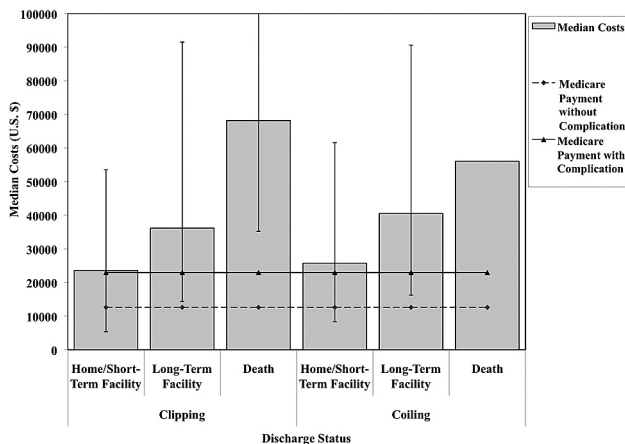


Fig 1. Median 2008 hospitalization costs for clipping and coiling of unruptured aneurysms compared with Medicare payments.

tributed.² Multivariate analysis to determine predictors of cost was performed by using a standard least-squares model. All statistical analysis was performed by using the SAS-based statistical software JMP (www.jmp.com).

Results

Hospitalization Costs in 2008

Hospitalization cost data are summarized in the Table. Multivariate analysis showed that increased age was not associated with higher costs for clipping ($P = .70$) or coiling ($P = .84$). Female sex was not associated with higher costs for clipping ($P = .42$) but was associated with higher costs for coiling ($P = .02$). Poor discharge status was associated with higher costs for both clipping ($P < .001$) and coiling ($P < .001$).

For 2008, the average Medicare payment for MS-DRG 27 was \$12,599 and increased to \$17,107 with complications or comorbidities (MS-DRG 26) and to \$22,946 with major complications or comorbidities (MS-DRG 25). Hospitalization costs and Medicare payments are compared in Fig 1.

Cost Trends with Time

Trends in costs for treatment of unruptured aneurysm are summarized in Fig 2.

Between 2001 and 2008, the inflation-adjusted cost for hospitalization for treatment of an unruptured aneurysm with

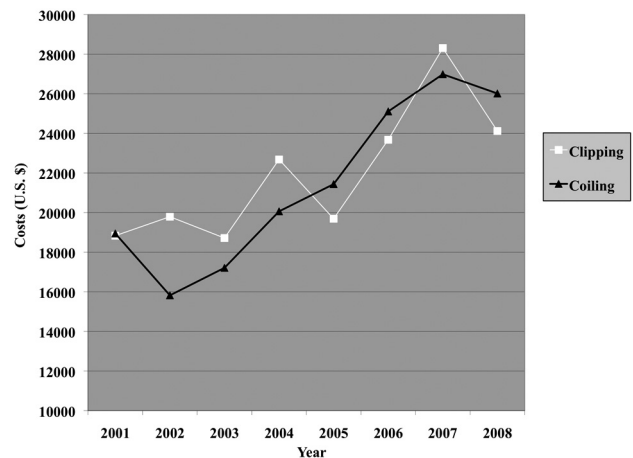


Fig 2. Median hospitalization costs for clipping and coiling of unruptured aneurysms, 2001–2008

surgical clipping increased from \$18,836 (IQR, \$13,910–\$26,677) to \$24,123 (IQR, \$18,775–\$31,523), which amounts to a 3.6% annual inflation rate. During this same time period, the costs associated with coiling of unruptured aneurysms increased from \$18,948 (IQR, \$14,031–\$28,762) to \$26,018 (IQR, \$17,544–\$37,001), which amounts to a 4.6% annual inflation rate.

Discussion

For uncomplicated treatments, the average Medicare payment in 2008 was \$12,599 (MS-DRG 27), which is substantially lower than the median 2008 hospital costs of \$23,574 for clipping and \$25,734 for coiling. The median hospital costs were \$36,188 for clipping and \$40,502 for coiling treatments complicated by major morbidity and \$68,165 for clipping and \$56,020 for coiling treatments complicated by mortality (Table). These costs are also substantially higher than the average Medicare payments for patients with major complications and comorbidities of \$22,946 for 2008 (MS-DRG 26). Twenty-four percent of patients undergoing clipping or coiling for unruptured aneurysms in the United States were ≥65 years of age,³ so Medicare patients represent a significant minority of these cases.

Hoh et al⁴ reported the cost of cerebral aneurysm treatment in a previous study using NIS data, showing that clipping was

associated with significantly longer stay and significantly higher total hospital charges than coiling for patients with both ruptured and unruptured aneurysms. We sought to delineate further the reasons for cost differentials in unruptured aneurysms by stratifying patients by age and outcome and by evaluating the trend in cost with time. When we separately assessed the hospital charges for patients undergoing clipping and coiling who did not have severe morbidity or mortality, we found that the charges are higher for coiling than for clipping. For these cases without complications, coiling was \$2,188 more expensive than clipping. This is likely due, in part, to the high costs of the endovascular devices used in the coiling procedure. In a single-center study from the Netherlands, Halke et al⁵ found that though clipping of unruptured aneurysms had higher costs related to the need for intensive care facilities and longer length of hospitalization, this difference was more than offset by the higher material cost of coils. Similarly, a single-center study of hospital charges for patients with unruptured cerebral aneurysms treated at the University of Florida found that device costs led to higher median charges for coiling versus clipping.⁶ Hospitalization costs for both coiling and clipping increased from 2001 to 2008, but the costs for the 2 procedures remained similar during that period (Fig 2). Although there were some statistical differences, costs for clipping and coiling were fairly similar, with clipping costing more than coiling in some years and coiling costing more than clipping in others.

Hoh et al⁶ found, in their single-center study, that older age tended to lead to higher hospital charges for both clipping and coiling of unruptured aneurysms, but they did not provide quantitative information about the degree of this association. We did not find an increase in costs related to age for either clipping or coiling.

The hospital costs for patients in the NIS treated for unruptured aneurysms was highly dependent on whether the procedure led to morbidity or mortality. For patients who had complications leading to morbidity and mortality, the cost of critical care overwhelmed the differences in periprocedural charges for coiling and clipping. Certainly, reducing morbidity and mortality would have a big impact on reducing hospital charges.

Later charges for follow-up imaging surveillance for aneurysm recurrence are likely to lead to widening of the difference in costs between coiling and clipping. Also, a higher recurrence rate of coiled aneurysms potentially leading to additional treatment with hospitalization will add further charges in a significant fraction of patients. International Subarachnoid Aneurysm Trial⁷ showed relatively little difference in re-rupture rates between coiled and clipped aneurysms. It is reasonable to expect that there would similarly be no significant difference in subsequent rupture rates of unruptured aneurysms, so differences in hospitalization for subsequent rupture of coiled versus clipped aneurysms are not likely to add to differences in hospital charges.

Large aneurysms⁶ and posterior circulation aneurysms might be associated with higher charges for either clipping, coiling, or both. The NIS provides no information on aneurysm size or location, so we could not evaluate these parameters. Another potential limitation of this study is the occurrence of coding errors, which are present in any large administrative data base.² However, errors in data bases of this type are probably randomly distributed because recording is done by clerical and coding staff remote from the study questions. Furthermore, random coding errors are probably diluted in such a large sample and thus not likely to affect overall conclusions. Another limitation is that the hospital charge data are given only as a total, so we are unable to evaluate individual components of those charges.

Conclusions

Hospitalization costs for patients undergoing clipping and coiling of unruptured cerebral aneurysms are substantially higher than Medicare payments. Efforts to decrease hospitalization costs and/or increase payments will be necessary to make these treatments of unruptured aneurysms economically viable for hospitals in the long term.

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