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Operative Times Have Remained Stable for Total Hip Arthroplasty for >15 Years

Systematic Review of 630,675 Procedures

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Background: Understanding trends in operative times has become increasingly important in light of total hip arthroplasty (THA) being added to the Centers for Medicare & Medicaid Services (CMS) 2019 Potentially Misvalued Codes List. The purpose of this review was to explore the mean THA operative times reported in the literature in order (1) to determine if they have increased, decreased, or remained the same for patients reported on between 2000 and 2019 and (2) to determine what factors might have contributed to the difference (or lack thereof) in THA operative time over a contemporary study period.

Methods: The PubMed and EBSCOhost databases were queried to identify all articles, published between 2000 and 2019, that reported on THA operative times. The keywords used were "operative," "time," and "total hip arthroplasty." An article was included if the full text was available, it was written in English, and it reported operative times of THAs. An article was excluded if it did not discuss operative time; it reported only comparative, rather than absolute, operative times; or the cohort consisted of total knee arthroplasties (TKAs) and THAs, exclusively of revision THAs, or exclusively of robotic THAs. Data on manual or primary THAs were extracted from studies including robotic or revision THAs. Thirty-five articles reporting on 630,675 hips that underwent THA between 1996 and 2016 met our criteria.

Results: The overall weighted average operative time was 93.20 minutes (range, 55.65 to 149.00 minutes). When the study cohorts were stratified according to average operative time, the highest number fell into the 90 to 99-minute range. Operative time was stable throughout the years reported. Factors that led to increased operative times included increased body mass index (BMI), less surgical experience, and the presence of a trainee.

Conclusions: The average operative time across the included articles was approximately 95 minutes and has been relatively stable over the past 2 decades. On the basis of our findings, we cannot support CMS lowering the procedural valuation of THA given the stability of its operative times and the relationship between operative time and cost.

Total hip arthroplasty (THA) procedural volume has surged considerably over the past few decades, with projections indicating that this growth will continue to increase in the years to come[1-4]. Part of this development can be attributed to the procedure's widespread success and high rates of postoperative patient satisfaction[5,6]. However, in order to maintain its success, there has been an increased emphasis on ways of handling increased caseloads while minimizing complication rates[7-9]. The relationship between complications and operative time has been explored extensively in this regard. However, there has been a lack of information regarding what a typical duration for the procedure should be, with multiple studies indicating that both prolonged[10-17] and shortened[18,19] operative times can lead to various complications after total joint arthroplasty. Therefore, understanding how operative times have adjusted as procedural volume has grown can help providers better understand the interplay between complication rates and THA duration.

Understanding trends in THA operative times has become especially important over the recent decades when considering physician reimbursement. As the Centers for Medicare & Medicaid Services (CMS) continue to reevaluate compensation

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appraisals for total joint arthroplasties, and in light of THA being added to the CMS 2019 Potentially Misvalued Codes List, information regarding operative time can help inform this discussion[20,21]. Furthermore, while the American Association of Hip and Knee Surgeons (AAHKS) and the Relative Value Scale Update Committee (RUC) of the American Medical Association (AMA) have collaboratively provided intra-service times accompanying total joint arthroplasty coding, to the best of our knowledge there has yet to be an analysis of operative times reported across the current literature to add to this understanding.

The purpose of this review was to explore average operative times for THA as reported in the literature over the past 2 decades. Our aims were (1) to determine if operative times for THA have increased, decreased, or remained the same for patients reported on between 2000 and 2019 and (2) to determine what factors might contribute to the difference (or lack thereof) in THA operative time over this contemporary study period.

Materials and Methods

Literature Search

The PubMed and EBSCOhost databases were queried to identify all articles, published between January 1, 2000, and April 7, 2019, that reported on THA operative times in the United States, as defined and reported by the authors of the published study. The following keywords were used with the AND or OR Boolean operators: "operative," "time," and "total hip arthroplasty." An article was included if the full text was available, it was written in English, and it reported operative times of THA procedures. An article was excluded if it did not discuss operative time; it reported only comparative, rather than absolute, operative times; or the cohort consisted of total knee arthroplasties (TKAs) and THAs, exclusively revision THAs, or exclusively robotic THAs. If data on manual or primary THAs could be extracted from an article on robotic or revision THAs, it was included.

Data Acquisition

The initial query yielded 1,335 manuscripts. Titles and abstracts were reviewed to identify articles that aligned with the purpose of our analysis. From this initial screening, 221 articles were selected for further review. After implementation of our inclusion and exclusion criteria, and thorough evaluation of each manuscript, 35 studies were included for our final review. A stepwise review of each article's reference list was also conducted. However, no additional articles were included. Our final analysis therefore included 35 articles, reporting on a total of 630,675 hips that underwent THA between 1996 and 2016 (Table I). Figure 1 depicts the publication selection process.

Results

Overall Operative Time Values

In the articles that reported the mean operative time for their respective cohorts, the overall weighted average was 93.20 minutes (Fig. 2)[16,17,22-25,27-54]. The range for the average of the times in each study were 55.65[53] to 149.00[49], and the range of the operative times for all individual cohorts included in the studies (most studies contained multiple cohorts) spanned 52.8 minutes[27] to 166 minutes[49]. Only one study[26] reported a median instead of a mean operative time, and the median in that cohort was 105 minutes.

Table II shows the operative time ranges across the individual cohorts in the included studies. At the extremes, 6 cohorts showed average operative times of <60 minutes[27,48,51,53] and 6 demonstrated average times of >120 minutes[41,45,49,52]. However, the range into which the most cohorts fell (n = 16) was 90 to 99 minutes. Similarly, this range was associated with the largest number of THAs (n = 582,965; 92.4%), with each large database study reporting a mean operative time within this range[22,25,28,31,33,35,39,47]. Interestingly, when we considered only studies that did not utilize a database, we found increased variability in the operative time reported for each contained cohort (Table III). The most common range in the articles reporting on institutional data or case series was 70 to 79 minutes (n = 10 cohorts), and the average operative time in those studies was 88 minutes.

Change Over Time

We defined stability on the basis of the proximity of reported values to the overall weighted mean over the study period. As a whole, operative time was stable over the included study ranges, as seen in Figure 2. This trend can primarily be seen in the larger database studies that examined THA duration over multiple years. Belmont et al. reported on the earliest cohort of patients in the National Surgical Quality Improvement Program (NSQIP) and found a mean operative time of 97.6 minutes for 17,638 THA procedures performed between 2006 and 2011[25]. In the database study with the latest and largest time frame (2006 to 2016) and the largest number of patients (n = 135,964), Grosso et al. demonstrated that operative time averaged 93.88 minutes and had not changed substantially over the study period[54]. In the second largest study, by Sodhi et al., the mean operative time was 94.00 minutes for 103,702 patients, further demonstrating a relative lack of change in THA duration[33].

While these larger cohorts are more likely to reflect usual operative times, studies that did not utilize databases seemed to indicate the opposite of what is currently being espoused by CMS: i.e., these studies indicated an increase in operative time over the years. For example, in the earliest study, which included 230 hips that underwent the procedure between 1996 and 1999, Woolson and Kang found an average operative time of 66.95 minutes[32]. This lower procedure duration in earlier years was also shown by Matta et al.[43], who found a mean operative time of 75.00 minutes in 494 patients treated between 1996 and 2004. Furthermore, 3 of the 4 most recent studies that did not utilize database data demonstrated some of the longest average operative times (>100 minutes)[40-42,44]. However, various confounding factors, such as small sample sizes and procedural learning curves, likely impacted these analyses. Grosso et al. presented conflicting findings, reporting that operative time had decreased between their 2006-to-2009 and 2014-to-2016 cohorts ($p < 0.001$), with the overall average for the 2 cohorts (93.88 minutes) remaining within the stable range described above[54].

TABLE I Summary of Articles Included in Our Analysis

Article (Year)	Patient Population Years	No. of Hips	Average Operative Time *(min)*	Study Details*
Woolson and Kang[32] (2007)	1996-1999	230	66.95	Compared resident involved vs. only an attending involved
Matta et al.[43] (2005)	1996-2004	494	75.00	Described case series of patients who underwent THA via single-incision anterior approach
Pagnano et al.[48] (2005)	2003-2004	200	60.00	Compared 2-incision technique vs. standard posterior approach
Desser et al.[49] (2010)	2004-2006	60	149.00	Compared 2-incision technique vs. anterolateral approach
Wang et al.[50] (2013)	2004-2010	425	79.00	Compared operative time among 6 groups stratified by BMI
Bernasek et al.[51] (2010)	2005-2006	92	59.07	Compared anterolateral vs. lateral approach
Goytia et al.[52] (2012)	2005-2007	81	110.68	Compared learning curve for anterior approach
Restrepo et al.[53] (2010)	2005-2007	100	55.65	Compared direct anterior vs. direct lateral approach in RCT
O'Malley et al.[16] (2012)	2005-2008	4,281	101.00	Reported complications and length of stay, and predictors of each, via NSQIP Database query
Haughom et al.[22] (2014)	2005-2012	13,109	96.21	Compared resident present vs. resident not present, NSQIP Database queried
Choi et al.[23] (2012)	2006-2008	194	97.90	Compared THA and TKA patients and short-term outcomes, via single-center registry
Della Valle et al.[24] (2010)	2006-2008	72	87.79	Compared mini-incision posterior approach vs. 2-incision technique in RCT
Belmont et al.[25] (2014)	2006-2011	17,638	97.60	Reported M&M in 30-day postop. period of THA, NSQIP Database queried
Gholson et al.[26] (2016)	2006-2012	30,361	105†	NSQIP Database queried
Grosso et al.[54] (2019)	2006-2016	135,964	93.88	NSQIP Database queried
Tischler et al.[27] (2015)	2007-2010	341	56.45	Compared intraop. fluoroscopic guidance vs. no fluoroscopic guidance
Schairer et al.[28] (2017)	2007-2013	42,692	92.13	Compared THA for femoral neck fracture vs. osteoarthritis, NSQIP Database queried
McLawhorn et al.[29] (2018)	2007-2014	2,018	95.00	Matched primary population with population in NSQIP who underwent conversion THA
Graves et al.[30] (2016)	2008-2010	221	79.78	Compared posterior vs. direct anterior approach
Yakubek et al.[31] (2018)	2008-2014	64,796	93.13	Compared non-COPD vs. COPD patients for short-term THA complications, NSQIP Database queried
Sodhi et al.[33] (2018)	2008-2015	103,702	94.00	NSQIP Database queried
Barrett et al.[34] (2013)	2010-2011	87	72.26	Compared direct anterior vs. posterior approach in RCT
Basques et al.[35] (2015)	2010-2012	20,936	94.31	Compared general vs. spinal anesthesia, NSQIP Database queried
Ponzio et al.[36] (2018)	2010-2012	4,538	74.85	Compared direct anterior vs. posterior approach
Sibia et al.[37] (2017)	2010-2015	2,698	88.51	Compared direct anterior vs. posterior approach, Crimson Continuum of Care electronic database queried
Raphael et al.[38] (2013)	2011	50	69.86	Compared normal-weight vs. overweight vs. obese vs. morbidly obese patients
George et al.[39] (2018)	2011-2015	94,326	93.30	Compared TKA vs. THA for readmissions, reoperations, and complications
Surace et al.[47] (2019)	2011-2015	89,802	91	Examined association between short-term complications and operative time, NSQIP Database queried
Schwarzkopf et al.[40] (2017)	2012-2015	251	129.00	Compared conversion vs. primary THA
York et al.[41] (2017)	2012-2015	50	124.00	Reported learning curve from first 25 THAs to second 25 THAs conducted via direct anterior approach
Ryan et al.[42] (2018)	2012-2015	163	110.00	Compared primary vs. conversion THA

continued

TABLE I (*continued*)

Article (Year)	Patient Population Years	No. of Hips	Average Operative Time *(min)*	Study Details*
Isaacson et al.[44] (2016)	2013-2014	92	76.30	Compared primary vs. revision THA
Masonis et al.[45] (2008)	Not available	300	116.27	Compared first 100 vs. middle 100 vs. last 100 of 1 surgeon's first 300 THAs conducted via direct anterior approach
Trinh et al.[46] (2015)	Not available	101	97.59	Compared anterior approach vs. other surgical approaches
Russo et al.[17] (2015)	Not available	210	81	Compared "normal and pre-obese" BMI vs. obese BMI

*RCT = randomized controlled trial, M&M = morbidity and mortality, and COPD = chronic obstructive pulmonary disease. †Only median operative time reported.

Surgical Technique

Differences in operative times across surgical techniques were examined in 10 studies[24,30,34,36,37,46,48,49,51,53]. Together, these studies indicated that technical approach had a variable influence on operative times.

Direct anterior and posterior approaches were compared in 4 studies[30,34,36,37], with a lack of consensus regarding which method yielded a shorter operative time. Graves et al. found no difference in the mean operative time between 86 patients undergoing an anterior approach and 135 patients undergoing a posterior approach (79 versus 81 minutes, $p = 0.411$)[30]. An anterior approach resulted in longer operative times in the analyses by Barrett et al. (84.3 versus 60.5 minutes, $p < 0.0001$) and Sibia et al. (90.4 versus 86.3

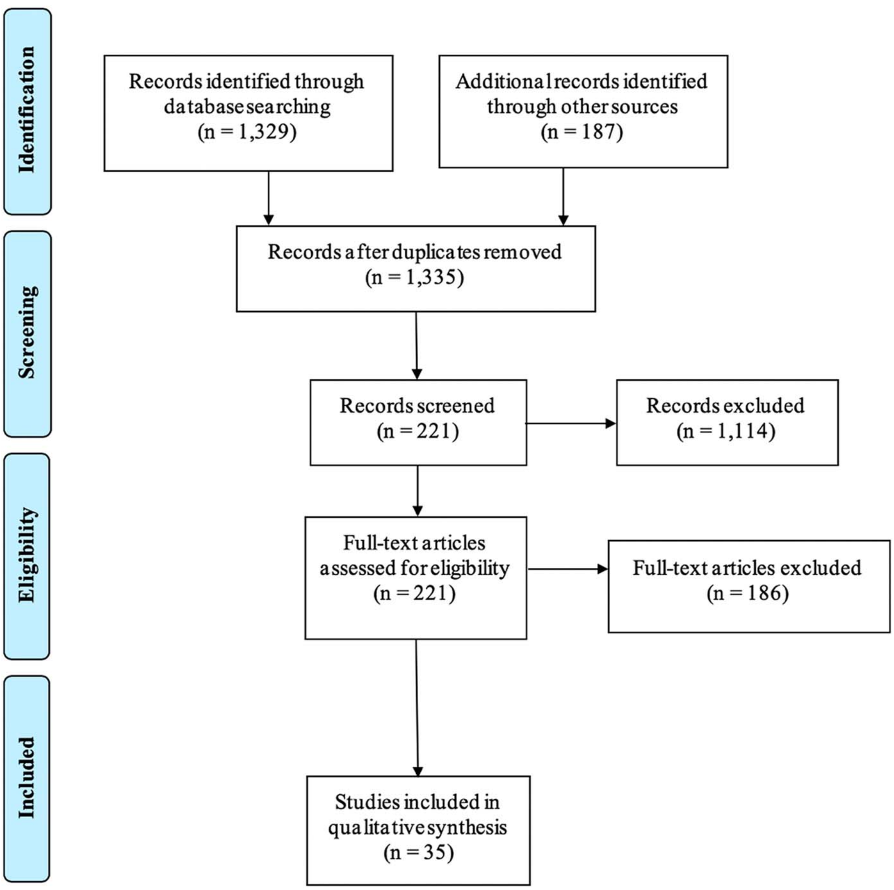

Fig. 1

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram depicting the selection process for publications included in the final analysis.

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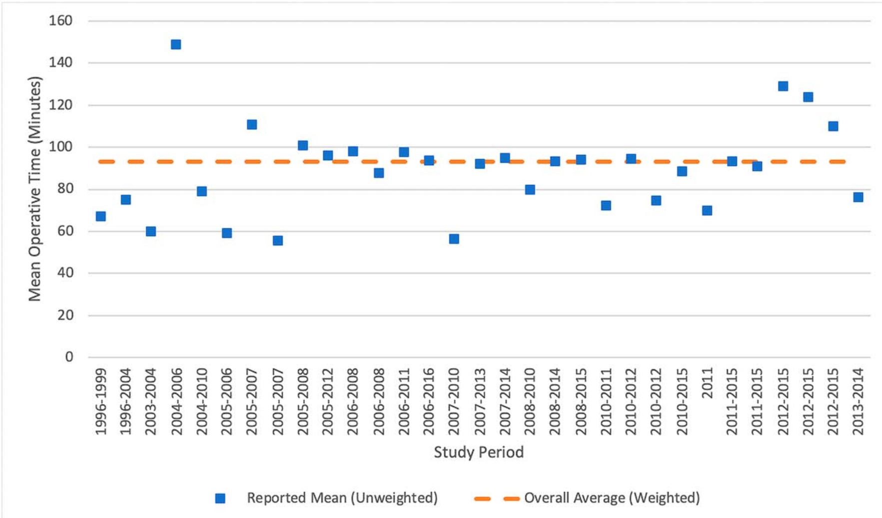

Fig. 2

Mean operative times for reported study periods. Each time period on the x axis corresponds to the time period of 1 included study (see Table I).

minutes, $p = 0.005$)[34,37]. Furthermore, Ponzio et al., who reported on the largest number of patients among studies comparing anterior and posterior techniques (n = 4,538), found that a posterior approach yielded a longer operative time (75.1 versus 71.1 minutes, $p < 0.001$)[36]. However, it is noteworthy that there was a sizeable difference in the sample sizes of the anterior (n = 289) and posterior (n = 4,249) groups[36].

The utilization of a 2-incision approach was analyzed in 3 studies[24,48,49], all of which indicated that this method yielded a relatively longer procedure duration. Della Valle et al. found that THAs done with this technique took longer than those using a mini-incision posterior approach (98 versus 77 minutes, $p = 0.0008$)[24], whereas Pagnano et al. and Desser et al. found that they took longer than those done through a standard posterior (68 versus 54 minutes, $p = 0.01$) or anterolateral (166 versus 132 minutes) approach[48,49].

The remaining studies analyzed anterolateral versus lateral, direct anterior versus direct lateral, and anterior versus posterior, anterolateral, and lateral approaches[46,51,53], with no differences found across these surgical techniques.

Learning Curve

The impact that the learning curve for THA procedures had on operative time was explored in 5 studies[22,32,41,45,52]. Three of these analyses examined the differences in operative time as a surgeon became more experienced[41,45,52], whereas the remaining 2 examined the impact of the presence of a trainee on the duration of the procedure[22,32]. There was consensus among the studies that more experience, along with the absence of a trainee, led to decreased operative times. Masonis et al. examined a single surgeon's experience with 300 consecutive THAs and found a significant difference between the first 100 (mean operative time: 132.8 minutes), second 100 (mean operative time: 109.9 minutes), and third 100 (mean operative time: 106.1 minutes) ($p < 0.001$)[45]. Similarly, York et al. found a significant difference in the mean surgical time between the first 25 procedures performed by a fellowship-trained surgeon (135.32 minutes) and the second 25 (113.91 minutes) ($p = 0.0052$)[41]. Furthermore, Woolson and Kang[32] and Haughom et al.[22] demonstrated that, when residents were present, operative time increased by 12 minutes ($p < 0.0001$) and 15 minutes ($p < 0.001$), respectively.

Impact of Body Mass Index (BMI)

Of the 35 studies included in this review, 3 compared operative time between patient groups stratified by BMI[17,38,50]. Across these analyses, increasing BMI was associated with longer operative times. Wang et al. found that patients in the BMI category of Obese Class III had a significantly longer mean operative time (97 minutes) than those who were underweight (71 minutes, $p < 0.001$), normal weight (74 minutes, $p < 0.001$), overweight (75 minutes, $p < 0.001$), in Obese Class I (82 minutes, $p < 0.001$), or in Obese Class II (86

TABLE II All Cohorts Stratified by Operative Time Ranges

Average Operative Time *(min)*	No. of Cohorts*
<60	6
60-69	6
70-79	10
80-89	5
90-99	16
100-109	6
110-119	2
≥120	6

*The number of cohorts does not equal the number of studies, as there were several cohorts in some studies.

TABLE III Cohorts Without Formal Database Utilization Stratified by Operative Time Ranges

Average Operative Time *(min)*	No. of Cohorts*
<60	6
60-69	6
70-79	10
80-89	3
90-99	6
100-109	2
110-119	2
≥120	6

*The number of cohorts does not equal the number of studies, as there were several cohorts in some studies.

minutes, $p = 0.011$)[50]. Similarly, Russo et al. found that operating room time was significantly lower for a combined cohort of normal-weight and pre-obese patients (75.9 minutes) compared with a combined cohort of patients in Obese Classes I, II, and III (88.6 minutes, $p < 0.0001$)[17]. No difference was found across individual obese classes ($p = 0.2908$)[17].

Discussion

As procedural volume for THA continues to rise, a better understanding of how operative times have changed over the years can help providers understand typical procedure duration. In our study, we found that the average operative time across included articles was approximately 95 minutes. Additionally, we found that operative time has been relatively stable over the past 2 decades. These findings are especially important given the fact that operative time is a main driver of cost (including the costs of the operating room time and the time of operating room staff, including nurses and surgical technologists).

Our study has some limitations. Since many of the included studies utilized the NSQIP, it is likely that operative times were double-counted in our review, potentially skewing the average. However, these articles reported on multiple time frames and included a high number of patients, suggesting that the reported average is likely an accurate estimate. Additionally, different hospitals may use different algorithms to calculate the duration of these surgical procedures. For example, while operative time should be recorded as the time from skin incision to skin closure, some institutions may begin recording at the time that anesthesia is administered or extend their recording to when dressings have been placed. Given that many of our included articles did not elaborate on the method of measuring operative time, the accuracy of the reported values cannot be validated. Furthermore, we focused only on operative times in the United States, which could limit the generalizability of our findings to international health-care systems. However, given the large number of hips included in this analysis, as well as the wide time range reported across studies, we believe that these findings can be useful for all surgeons performing THA.

An increase in operative time would be expected over a contemporary time frame given the increased BMI and higher comorbidity burden associated with modern-day total joint arthroplasty patient populations[4,41,45,52,55-58]. These characteristics can increase the difficulty of a procedure and thus prolong intra-service time. This was made evident by the articles included in our analysis that reported on BMI, which all demonstrated a direct relationship between BMI and operative time[17,38,50]. Additionally, various studies have indicated that increased patient comorbidity burden can result in a variety of adverse outcomes, such as increased complication rates, length of hospital stay, and mortality following total joint arthroplasty[16,25,26,31,38,50,56,59-64]. Increased complexity similarly prolongs operative times. Specifically, in our analysis, Gholson et al. found that congestive heart failure was associated with a 20-minute increase in operating room time[26].

Other factors likely play a role in our findings regarding stable THA operative times. Notably, with the advent of various new technologies, along with an increased focus on preoperative planning modalities, providers are likely addressing the increased complexity of their patients' medical conditions through perioperative management of potential risks. Subsequently, adult reconstruction surgeons are able to maintain safe operative times despite the higher level of difficulty associated with these comorbidities[65].

An additional factor contributing to the stable operative time for THAs over the last 20 years could be related to the learning curve associated with implementing THA procedures in practice[22,32,41,45,52,55]. Although operative time decreases as surgeons become more comfortable and familiar with the procedure, having an innovative practice that incorporates the newest approaches and techniques likely contributes to increased operative times during this period of adjustment. For example, there has been an increase in the adoption of the anterior approach to THA[66,67], which may be associated with an inherent learning curve. While additional analyses with larger cohorts are needed to determine the impact of this factor on operative time trends, it is important to consider the importance of continually trying new technologies and techniques. Notably, the transition from cementless to cemented THA approximately 20 years ago led to improved functional outcomes, prolonged implant survivability, and shortened operative times[68-70].

Another factor affecting operative time may be that, as the procedural volume continues to rise, resident and fellowship programs may be more comfortable allowing trainees to participate in the procedure itself.

In conclusion, the average operative time across the articles included in this systematic review was approximately 95 minutes, and this operative time was relatively stable over the past 2 decades. Increased BMI and less surgeon experience both were associated with increased operative times. Future studies should examine the relationship between operative time and patient-related factors and adverse outcomes over a similar study period. Given the stability in operative times found in our systematic review, and the relationship between operative time and cost, we cannot support lowering the procedural valuation by CMS. ■

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