ORIGINAL ARTICLE

The Impact of Age and Medicare Status on Bariatric Surgical Outcomes

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Hypothesis: Medicare status and increasing age are associated with poor outcomes from bariatric surgical procedures.

Design: Survey.

Setting: National sample of hospitalized patients in the United States.

Patients and Intervention: Adult patients undergoing bariatric surgery in 2001 and 2002.

Main Outcome Measures: Mortality and adverse events.

Results: We assessed 25 428 bariatric procedures with logistic regression, finding that age (odds ratio, 1.04; 95% confidence interval, 1.02-1.07), male sex (odds ratio, 2.45; 95% confidence interval, 1.48-4.03), electrolyte disorders (odds ratio, 13.91; 95% confidence interval, 8.29-23.33), and congestive heart failure (odds ratio, 4.96; 95% confidence interval, 2.52-9.77) were independent risk factors for bariatric surgery mortality. Adverse outcomes increased as a function of age in a nearly linear fashion, with a steep increase after the age of 65 years. Most Medicare patients undergoing these operations were younger than 65 years and had a much greater disease burden than non-Medicare patients.

Conclusions: Age, male sex, electrolyte disorders, and congestive heart failure were independent risk factors for bariatric surgical mortality. Limiting bariatric surgical procedures to those younger than 65 years is warranted because of the high morbidity and mortality associated with these operations in older patients.

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BARIATRIC SURGICAL OUTcomes are uncertain for older patients. Several series have shown in older patients that either complication rates or mortality is increased[1-3] or the procedures are safe and associated with the similar good outcomes observed in younger patients.[4-6] In part, this discrepancy in the surgical literature results from analyses of relatively small series of older patients. There have been several major evidence-based reviews[7-18] of bariatric surgery published in the past several years. Each of these reviews concluded that there was inadequate information regarding older patients to recommend for or against bariatric surgical procedures. Most important, Medicare assembled a medical care advisory committee to review the available literature supporting application of bariatric surgery to the Medicare population. The committee concluded that there were insufficient data to arrive at recommendations relevant to the Medicare patients.[14]

The major issues needing clarification are the perioperative safety for weight loss operations and long-term weight loss and comorbidity control for older and other Medicare-eligible patients. The present study was performed to determine the perioperative safety of bariatric procedures as performed in the United States on Medicare patients. We queried the National Inpatient Survey (NIS) to determine in-house outcomes for bariatric surgical operations on Medicare beneficiaries. The NIS database is extremely large, containing discharge information for 20% of all US hospitalizations, and contains sufficient numbers of bariatric procedures such that outcomes relevant for the Medicare population can be assessed. This database analysis overcomes limitations inherent in single-institution reports of perioperative complications for older patients. Analyses from national databases provide outcomes that are objective and reflective of average outcomes for these procedures as practiced in the United States.

See Invited Critique at end of article

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METHODS

DATABASE ACQUISITION AND CASE IDENTIFICATION

The NIS was obtained from the Agency for Healthcare Research and Quality for 2001 and 2002. These years were selected because they had many bariatric procedures performed. The NIS is a population representative sampling of hospital discharges obtained from 20% of all the hospitalizations in the United States in any given year. In contrast to the other large hospital discharge database (the National Hospital Discharge Survey [NHDS]), which samples a fraction of discharges from any given hospital, the NIS obtains information about all discharges from a select number of facilities in the United States. This has the advantage of providing the full spectrum of activity from hospitals in various regions. Although statistically corrected to be population representative, data are only collected from hospitals in 29 states and ethnicity data are often incomplete. Thus, there are regions and populations that may not be well represented in the NIS. The major advantages of the NIS are the completeness of information from individual hospitals facilitating volume-outcome analysis. Hospital charges are available in the NIS, enabling studies relating to the cost of care.

Bariatric procedures were identified by having diagnosis-related group (DRG) 288. Diagnosis-related groups are assigned at the patient's discharge based on combinations of diagnostic and procedure codes along with information from the patient's medical record to best reflect the primary reason a patient was hospitalized. Diagnosis-related group 288 is for patients whose primary reason for hospitalization was to undergo procedures related to morbid obesity. Thus, any patient encoded with DRG 288 was admitted with the intent to perform an operation for a problem related to the patient's morbid obesity. Operations associated with plastic surgical procedures (ie, those with *International Classification of Diseases, Ninth Revision, Clinical Modification* [*ICD-9-CM*] procedure codes ranging from 85.XX to 86.XX) were excluded. Operations encoded as 44.XX and 45.XX along with DRG 288 were considered to be bariatric surgical procedures.[19] Adverse outcomes were defined as having a length of stay exceeding the 95th percentile, being discharged to a long-term care facility, or having died while in the hospital during the admission for the weight loss operation. Three major analytic groups were assessed: those younger than 65 years and having medical insurance other than Medicare, those younger than 65 years with Medicare insurance, and those 65 years and older. Nearly all patients (85.7%) 65 years and older had Medicare insurance. Respondents in this age category were considered as a single group.

Factors contributing to adverse outcomes were determined by univariate and multivariate statistical analysis using the SAS statistical software package (SAS Institute Inc, Cary, NC).

ELIXHAUSER COMORBIDITY ANALYSIS

The disease burden for any patient was modeled using the Elixhauser comorbidity algorithm for identifying relevant comorbid conditions.[20] Comorbidity software, version 3.0, was obtained from the Agency for Healthcare Research and Quality (http://www.hcup-us.ahrq.gov/toolssoftware/comorbidity/comorbidity.jsp#download).

Each of the comorbidity variables was tested for its contribution as a predictor of adverse events by χ^2 analysis. Those factors that significantly contributed to adverse events were entered into a logistic regression equation as independent variables, with adverse events as the dependent variable. The regression was run with backward elimination. The Elixhauser variables that remained significantly related to adverse events following backward elimination were used for subsequent modeling analyses.

DEVELOPMENT OF A BARIATRIC SURGERY–SPECIFIC RISK ASSESSMENT TOOL

The NHDS databases for January 1993 to December 2003 were acquired from the Centers for Disease Control and Prevention Web site (http://www.cdc.gov/nchs/about/major/hdasd/nhds.htm) and the Inter-University Consortium for Political and Social Research Web site (http://www.icpsr.umich.edu/index-medium.html). The NHDS is the principal database used by the US government for monitoring hospital use. Each year, approximately 300 000 hospital discharges are selected for entry into the NHDS from the 35 000 000 total discharges nationally. The NHDS uses a complex multistage design to ensure that the database is representative of the US population. By using US census information, the Centers for Disease Control and Prevention provide statistical weighting factors for each patient entry in the NHDS database that accounts for the survey's design facilitating disease and procedure incidence estimates. These weighting factors were used to determine the national incidence of bariatric operations.

Bariatric procedures were identified using the same algorithm previously described for the NIS database. We used NHDS as far back as 1993 because that was the first year DRG information was available in the databases we had access to. The data set of bariatric procedures extracted from the NHDS was used to build a comorbidity risk-adjustment model specific for assessment of bariatric surgery outcomes with administrative databases.

TREATMENT COMPLICATIONS

Treatment complications were identified with the Agency for Healthcare Research and Quality's clinical classification software (http://www.ahrq.gov/data/hcup). The clinical classification software divides diagnosis and procedure lists into related groups facilitating analysis of large administrative databases. We used the clinical classification software multilevel hierarchical diagnostic categories. These classify *ICD-9-CM* codes into 1 of 259 mutually exclusive categories with up to 4 subcategories. The identification of surgical complications was facilitated by analysis of the individual complications that compose the "238 complications of procedures" diagnostic category.

RESULTS

The combined NIS 2001 and 2002 databases had 15 306 709 records. Of these records, 27 795 were encoded with DRG 288. These were used as the basis for all subsequent analysis. There were 25 428 weight loss operations within DRG 288, with 84.1% of the procedures performed on female patients. The median age of the patients was 41 years (age range, 15-90 years). The median length of stay was 3 days (range, 1-89 days). Of the patients undergoing weight loss operations, 80.7% had a length of stay of 4 days; and the 95th percentile for length of stay was 7 days. With continuous data, outliers are usually defined as having values beyond 2 SDs from the mean or in the 95th percentile. Because length-of-stay data are not normally distributed, we used median values to assess length of stay and defined outliers

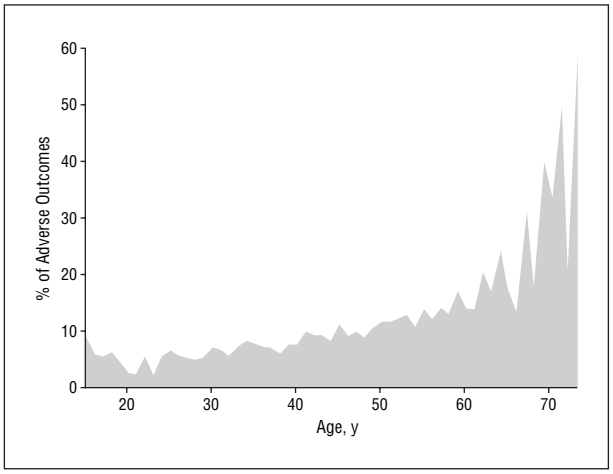

Figure. Distribution of adverse outcomes as a function of age. The ordinate represents the fraction of individuals in any age category experiencing adverse outcomes.

Table 1. Data for Risk Factors, Adverse Events, Mortality, and Procedures for Bariatric Surgery in the United States, 2001-2002*

Variable	Those <65 y: Without Medicare Insurance	Those <65 y: With Medicare Insurance	Those ≥65 y
Age, y†	41 ± 10	46 ± 10‡	68 ± 4§
Male sex	16.0	21.0‡	26.0§
Congestive heart failure	12.0	6.8‡	11.2§
Complicated diabetes mellitus	1.0	3.2‡	5.6§
Electrolyte disorder	2.9	5.9‡	15.8§
Anemia	2.2	3.8‡	4.6§
Depression	14.2	19.6‡	12.2§
Annual income <$25 000	2.0	5.0‡	5.0§
Adverse events	8.0	21.6‡	32.3§
Mortality	0.2	0.7‡	3.2§
No. of procedures	58 080	3594	478

*Data are given as percentage of each group unless otherwise indicated.
†Data are given as mean ± SD.
‡$P<.05$, χ^2 analysis, for Medicare vs non-Medicare group, younger than 65 years.
§$P<.05$, χ^2 analysis, for the non-Medicare group, those younger than 65 years vs those 65 years and older.

as being at or beyond the 95th percentile. Thus, we used a length of stay of 7 days or more as the hospitalization duration component for the adverse event definition. Of the 196 patients 65 years and older, 28 (14.3%) had not been designated as having Medicare insurance. All patients 65 years and older were considered as a single analytic group.

The **Figure** shows the adverse event rate as a function of age, which, in general, increased with increasing age. For those 65 years and older, the adverse event rate exceeded 20%. The mean adverse event rate for non-Medicare patients younger than 65 years was 8.0%, compared with 21.6% for Medicare patients younger than 65 years and 32.3% for patients 65 years and older (**Table 1**). Mortality was similarly higher in these latter 2 groups. Significantly fewer Medicare patients and patients 65 years and older were female.

Medicare insurance status and age may independently influence outcomes or be associated with other medical conditions (ie, confounding factors) that explain their apparent relationship with adverse outcomes. Sequential logistic regression modeling with inclusion of known risk factors for adverse outcomes in addition to Medicare status and age was used to determine the relative importance of individual risk factors on outcomes of bariatric surgery. Before performing this modeling, risk factors associated with adverse outcomes had to be identified. Furthermore, they needed to be identified on a data set other than the one being analyzed. This was accomplished by application of logistic regression modeling of the Elixhauser comorbidity variable contribution to adverse event prediction for bariatric surgery in the NHDS data set. Of the 29 Elixhauser variables, 22 did not significantly contribute to adverse events, as assessed by χ^2 analysis, and were not included in the regression procedure: valvular heart disease, pulmonary circulation disease, peripheral vascular disease, paralysis, other neurological disorders, hypothyroidism, renal failure, liver disease, peptic ulcer disease, acquired immune deficiency, lymphoma, metastatic cancer, solid tumor without metastasis, rheumatoid arthritis/collagen vascular disease, obesity, weight loss, chronic blood loss anemia, alcohol abuse, other drug abuse, psychoses, coagulopathy, and hypertension.

Seven variables were statistically related to adverse events for bariatric procedures in the NHDS database: congestive heart failure, chronic pulmonary disease, diabetes mellitus, diabetes mellitus with long-term complications, fluid and electrolyte disorders, deficiency anemias, and depression. Age and male sex were also statistically related to adverse events. These 9 variables were entered as independent variables into a stepwise elimination logistic regression equation, with adverse events serving as the independent variable. With the stepwise procedure, 2 variables were eliminated: chronic pulmonary disease and diabetes mellitus. Regression results are presented in **Table 2**. The relative frequency of these risk factors in the groups analyzed in the NIS database is presented in Table 1.

We used the variables identified in the previously described analysis to determine the contribution of Medicare status to bariatric surgery–related mortality. We elected to model mortality rather than adverse events because it is an unambiguous outcome manifested by better fits for the models than when adverse events was used as the dependent variable (data not shown). Sequential regression analysis with various models was performed with mortality as the dependent variable (**Table 3**). Medicare status alone would seem to be a significant predictor of mortality if it is entered as the only explanatory (independent) variable for bariatric surgery–related mortality. Subsequent inclusion of age in the regression model reduces the odds ratio for Medicare status and improves the model's fit. The addition of male sex had little effect on the Medicare or age variables but was a significant predictor for mortality. The addition of the medical morbid conditions found significantly related to bariatric surgery–associated mortality and in the NHDS modeling study

Table 2. Adverse Event Prediction Model for Bariatric Surgery*

Adverse Event	β Coefficient	Odds Ratio (95% Confidence Interval)
Congestive heart failure	2.12	8.34 (4.68-14.83)
Electrolyte disorder	1.53	4.56 (2.66-7.81)
Complicated diabetes mellitus	1.11	3.03 (1.20-7.66)
Anemia	1.08	2.93 (1.39-6.19)
Male sex	.47	1.60 (1.15-2.22)
Age	.03	1.03 (1.02-1.05)
Depression	–.71	0.49 (0.27-0.92)

*Data for this analysis were derived from the National Hospital Discharge Survey, January 1993 to December 2003. Adverse events following bariatric procedures were the dependent variables. Only those Elixhauser comorbidity variables that were significantly associated with adverse events with univariate analysis (χ^2 analysis, $P<.05$) were included in the regression model. The β coefficients in this model reflect those resulting from backward elimination of all the significant Elixhauser comorbidity variables along with age and male sex as independent variables. The intercept was –4.33, and the C index was 0.68.

eliminated the significance for Medicare status. Medicare status as a risk factor for bariatric surgery–associated mortality seems to be related to age and medical comorbidities and not to the fact that Medicare covers these patients' insurance. Of the medical comorbidities, electrolyte disorders and congestive heart failure most significantly associated with bariatric surgery–related mortality. Poverty (annual income <$25 000) was modeled as a risk factor for mortality and was not significantly (P=.13) correlated.

Table 4 summarizes surgical complications observed in the groups assessed in this study. Problems related to the respiratory system were the most frequent complications observed in the Medicare and non-Medicare groups younger than 65 years. Gastrointestinal tract complications were the most frequent for those 65 years and older. Technical complications manifested by intraoperative lacerations were reasonably frequent, occurring in 10.2% to 15.8% of procedures in all the groups studied.

COMMENT

Our principal finding was that of an increasing adverse event rate and mortality with advanced age. As was observed in other studies[1-3] of perioperative risk for bariatric procedures, male sex was an independent risk factor for undesirable outcomes. Age was an independent risk factor for mortality, as were electrolyte disorders and congestive heart failure. Medicare status itself was not a significant risk factor for mortality once corrected for age and medical comorbidities. Our intent was to study perioperative outcomes as a function of age and determine if upper age limits for bariatric surgery are appropriate. Adverse event rates progressively increased with age, exhibiting a sharp increase at older than 60 years. Beyond the age of 65 years, the adverse event rate exceeded 20% and mortality was 3.2%. Compared with younger individuals, older patients have less weight loss and comorbidity control following bariatric procedures.[5] Given that the operations may not be as effective in elderly persons relative to young persons and that there are high adverse event and mortality rates for older patients, limiting bariatric procedures to those younger than 65 years may be appropriate.

There are limited data regarding outcomes for bariatric procedures in elderly persons. Series that have been published include relatively few elderly patients, none of whom were systematically operated on. Enrollment criteria for older patients into the bariatric programs that have reported outcomes have not been standardized and little is known regarding the patients who were evaluated and rejected for surgery and for what reasons. It is likely that older patients described in these case series represented a select population of patients with the most favorable operative risks. For example, in our own series, older patients were only accepted for surgery if they were optimal candidates. Even with selection, we found a 3.5% mortality for patients 55 years or older compared with a 1.2% mortality for those younger than 55 years.[1]

Further complicating determination of age thresholds for these procedures is that prior series had no consistent definition for what age is considered "older." These definitions have ranged from ages in the 50s[1,3,4,6,21-24] to the 60s.[5,25,26] These studies have also reported results for a variety of operations. Mortality has ranged from 0% to 8.0% for older patients.[3,4] Most series[1,24,25] report complication rates that are equivalent for older and younger patients, although one series[26] reported higher complication rates for older patients. In general, there is less weight loss with older patients[5,21,25] and comorbidity control is not as good in older relative to younger patients.[5,24,25] Our results are unique in that, to our knowledge, they represent the first reporting of population-based perioperative outcomes for older individuals undergoing bariatric surgery. Being derived from a sampling of all US hospital discharges, these results are more reflective of expected outcomes from US community hospitals than those reported from single specialized institutions. Analysis of administrative databases is limited, however, because of imprecise disease and procedure coding and lack of detailed patient-specific information. Nevertheless, we did find that mortality and adverse event rates are higher in older patients. Taken together with our findings, bariatric surgery for patients 65 years and older may pose greater risks than any potential benefits that might be derived.

Relatively little is known about the outcomes for bariatric surgery in the Medicare insured. Medicare provides health insurance for all elderly persons in the US population and for younger individuals with serious disabilities. We found that only a small fraction of the patients undergoing bariatric procedures paid for by Medicare are 65 years and older. Thus, most of those undergoing these operations in the Medicare population are younger than 65 years and presumably disabled. Perioperative outcomes for these individuals are not as good as for the non-Medicare insured who are also younger than 65 years, factors that must be considered before bariatric surgery can be offered to this popula-

Table 3. Regression Modeling of the Effect of Various Risk Factors on Bariatric Surgery–Related Mortality

	Variable*								
Model	Medicare Status	Age	Male Sex	CHF	Complicated Diabetes Mellitus	Electrolyte Disorder	Anemia	Depression	C Statistic†
1	4.31 (2.46-7.54)‡	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.58
2	2.37 (1.29-4.36)‡	1.07 (1.04-1.09)‡	. . .	. . .	. . .	. . .	. . .	. . .	0.68
3	2.30 (1.25-4.22)‡	1.06 (1.04-1.09)‡	2.74 (1.69-4.45)‡	. . .	. . .	. . .	. . .	. . .	0.72
4	1.44 (0.74-2.81)	1.04 (1.02-1.07)‡	2.45 (1.48-4.03)‡	4.96 (2.52-9.77)‡	0.58 (0.13-2.64)	13.91 (8.29-23.33)‡	0.57 (0.13-2.44)	0.80 (0.38-1.76)	0.81

Abbreviation: CHF, congestive heart failure

*Data are given as odds ratio (95% confidence interval). The sequential addition of independent variables to the regression equation has the effect of statistically correcting for the factor.

†The C statistic is a measure of the model's ability to predict outcomes, with C = 0.5 suggesting the model does not predict outcomes at all and C = 1.0 meaning that the model perfectly predicts an outcome.

‡Significant at $P<.05$.

Table 4. Surgery-Related Complications Observed for Patients Experiencing Adverse Events

		Event Rate per 1000 Patients		
Complication	*ICD-9-CM* Code	No Medicare Insurance	Medicare Insurance (Those <65 y)	Those ≥65 y
Surgical complication				
Respiratory tract	9973	21.1	34.4	20.4
Gastrointestinal tract	9974	19.7	24.8	30.6
Unintentional operative laceration	9982	11.3	15.8	10.2
Hemorrhage-complicating procedures	99 811	8.7	7.6	10.2
Surgery-related complications				
Cardiac	9971	6.8	15.2	15.3
Urinary tract	9975	3.7	6.2	10.2
Postoperative infection	99 859	4.4	6.9	5.1
Postoperative wound disruption	9983	1.5	3.4	0
Iatrogenic hypotension	4582	0.9	2.1	10.2
Pulmonary embolism	41 511	0.8	4.1	0
Foreign body left during a procedure	9984	0.2	0	0

Abbreviation: *ICD-9-CM*, *International Classification of Diseases, Ninth Revision, Clinical Modification*.

tion. Being that the Medicare and non-Medicare populations are so different, results from long-term follow-up studies are not likely to be comparable. Taken together, these observations make estimation of the risk-benefit ratio for Medicare-insured patients younger than 65 years uncertain. Medicare is assessing its coverage policy for bariatric surgery. The medical care advisory committee concluded that there was insufficient information to determine the suitability of these procedures for the Medicare population.[14] Our findings suggest that these operations are not appropriate for those 65 years and older. Given that there is a substantially higher adverse event rate in Medicare patients younger than 65 years compared with non-Medicare patients of the same age, the appropriateness of these procedures in the younger Medicare population is questionable. Our findings suggest that further evaluation of the perioperative morbidity and mortality and long-term outcomes should be performed for this population.

We have used the concept of adverse events to represent undesirable outcomes following bariatric operations. Weight loss surgical procedures are always elective procedures. As such, any outcomes that result in a patient's death, prolonged hospitalization, or discharge to a nursing home are undesirable. We have adopted the concept of prolonged hospitalization defined as a median length of stay above the 95th percentile. This serves as a necessary proxy for complications because of difficulties in identifying complications in administrative databases and lack of consistency in defining complications and their ramifications. To our knowledge, no classification of complications and their effect on outcomes for patients undergoing bariatric surgery has been developed. Major complications of bariatric procedures include anastomotic leak, sepsis, pneumonia, and wound disruption. These are usually associated with prolonged hospitalization. Our previous studies of bariatric surgical outcomes using administrative databases demonstrated that *ICD-9-CM* complication-specific coding was an unreliable

indicator for undesirable outcomes. Approximately half of the patients that were encoded with diagnostic codes specific for complications had evidence of prolonged hospitalization or any other clinically significant manifestation of postoperative complications. In contrast, half of the patients with unexpectedly long postoperative lengths of stay had no *ICD-9-CM* codes specific for any complications. Given that coding of administrative databases is imperfect, we found that prolonged hospitalization as an undesirable outcome was a more effective proxy for procedure complication rates than *ICD-9-CM* diagnostic coding.[19]

The Elixhauser variables were entered into a probability model to adjust for the effects that comorbid conditions have on adverse events. By using a database other than the one we used for studying the relationship between age and bariatric surgery–related mortality, we developed a model for assessing the risk of adverse outcomes from bariatric surgery. This model facilitated adjustment for the effect of comorbid conditions on adverse events rather than mortality for assessment of bariatric surgical outcomes in administrative databases. To retain the maximum contribution to observed variance by individual independent variables, we entered each of the comorbid conditions into the regression equation rather than developed a composite score. Similarly, we entered age into the regression equation as a continuous rather than categorical variable to maximize its ability to explain the observed mortality variance. We found that Medicare patients were older, were more likely to be male, and had greater frequencies of significant comorbid diseases. Statistical correction for these factors eliminated an independent effect of Medicare status on bariatric surgery mortality. For Medicare patients younger than 65 years, the presence of comorbid conditions probably accounts for higher mortality than in non-Medicare patients. When assessing these patients for weight loss surgery, careful consideration to comorbid diseases is warranted.

In conclusion, of all patients undergoing bariatric operations in the United States, only 6% are covered by Medicare insurance and 0.8% are 65 years and older. Adverse event rates exceed 20% and in-house mortality is 3.2% for patients 65 years and older. Limiting bariatric operations to those patients younger than 65 years is an acceptable policy for bariatric surgery programs. The safety and efficacy of these operations for Medicare-insured patients younger than 65 years warrant further study.

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