Outcomes of surgery among the Medicare aged: Mortality after surgery

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This study examines post-surgical mortality, up to 1 year after surgery, for eight common operations among aged Medicare enrollees. The operations with the highest mortality in the 1.5 months after surgery were femur fracture reduction, hip arthroplasty (other, i.e., not total replacement), and coronary artery bypass. Mortality was still above average for femur fracture reduction, hip arthroplasty (other), and transurethral prostatectomy 1 year after surgery. The highest mortality rates following surgery were for people 85 years of age or over. This raises the following question: Should certain elective surgery be performed at younger ages if it appears that surgery may eventually be needed?

Introduction

In recent years, the incidence of surgery among the Nation's aged has increased at a far greater rate than for younger people (Lubitz and Deacon, 1982). In 1965, the number of operations per 1,000 aged persons was 105; in 1977, 166 operations per 1,000 aged were performed, a 58-percent increase. For the population 64 years of age or under, surgery rates were 74 per 1,000 in 1965 and 92 per 1,000 in 1977, a 24-percent increase. The increase in surgery among the aged no doubt reflects technical advances that offer hope of relief from chronic conditions associated with aging. These advances include improved techniques of lens extraction, the development of coronary artery bypass surgery, and the emergence of new materials in the field of orthopedic surgery. Accompanying these advances have been developments in anesthesiology and post-surgical care that allow physicians to operate on aged patients who would not, formerly, have been considered good candidates for surgery.

The increase in the rate of surgery raises questions about the risks of surgery among the aged. The purpose of this article is to present patterns of post-surgical mortality, including deaths occurring both in the hospital and after discharge. Mortality after eight common surgical procedures is studied for Medicare enrollees 65 years of age or over. The procedures are:

- Transurethral resection of the prostate (TURP).
- Cholecystectomy.
- Inguinal hernia repair.
- Lens extraction.
- Hip arthroplasty (total replacement).
- Hip arthroplasty (other, i.e., not total replacement).
- Femur fracture reduction.[1]
- Coronary artery bypass.

In 1980, hospital discharges for these operations constituted 23 percent of the 3.1 million total surgical discharges among the 26.5 million aged persons enrolled under Part A of Medicare. These procedures were selected because (with the exception of coronary artery bypass) they are among the most frequently performed on the aged. Coronary artery bypass was chosen because it represents a highly technical procedure performed with increasing frequency, and new information on the risks and benefits has recently appeared (Coronary Artery Surgery Study, 1983a and b). Another reason for including coronary artery surgery is that relatively little is known about the outcomes of this surgery for aged patients (Chassin et al., 1985).

These procedures, with the exception of femur fracture reduction, are elective to some degree (Cageorge et al., 1981; Wennberg et al., 1980). Thus, avoiding some of these operations might reduce the associated mortality. Wennberg et al. (1982) examined the implications of physician disagreement and uncertainty over indications for surgery and the benefits of different operations. The authors believe this professional disagreement is a major source of variation in surgery rates (and, by implication, in adverse outcomes of surgery) for different operations among different populations. Wennberg et al. stressed that public dissemination of improved information on surgical outcomes (such as mortality) is an important step toward encouraging more informed professional decisionmaking in this area.

Many studies have found large geographic variations in the incidence of surgery, apparently unrelated to variations in need, within areas of New England (McPherson et al., 1982) and within the States of Kansas (Lewis, 1969), Wisconsin (Detmer and Tyson, 1978), and New York (Lembcke, 1952). Large variations in surgical rates were also found within the Canadian Provinces of Ontario (Stockwell and Vayda, 1979) and Manitoba (Roos and Roos, 1981). If some of the operations performed in areas with high rates of surgery are really not necessary, then the mortality associated with this surgery may also not be necessary. Some deaths might be avoided if the indications for surgery were more strictly defined.

This article presents national mortality statistics for eight surgical procedures performed on the aged. Mortality is not limited to in-hospital deaths but is

[1]Although the *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* surgical codes do not identify the specific part of the femur that is fractured, for aged patients the majority of breaks occur at the neck of the femur. In this study, more than 90 percent of patients with a diagnosis of a fractured femur had a fracture at the neck of the femur.

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tracked for periods up to a year after surgery. The mortality experience of surgery patients is compared with mortality patterns in the general Medicare aged population. Variations in risk among age and sex categories are presented, and comparisons are drawn among regions of the United States in terms of mortality rates. Because about 95 percent of all people 65 years of age or over are covered by Medicare, these data generally represent the surgical outcomes of the aged in the United States and thus expand on studies limited to the surgical outcomes in selected hospitals or groups of hospitals. In addition, these data expand on those studies because they track deaths that occurred up to 12 months after discharge.

Future studies of surgical outcomes among Medicare patients will address the relationship between mortality and surgical volume by hospital and describe the rehospitalization experience of aged Medicare beneficiaries undergoing selected operations.

Methods

Data for this study were obtained from two files of the Medicare Statistical System of the Health Care Financing Administration (HCFA): the Medicare Provider Analysis and Review (MEDPAR) file and the enrollment file. The MEDPAR file contains information on discharges from short-stay hospitals for a 20-percent sample of Medicare beneficiaries, selected on the basis of their Medicare identification numbers. The information includes demographic data (e.g., age, sex), hospital data (e.g., size, location), and information about the stay (e.g., principal surgical procedure, principal diagnosis, and patient survival in the hospital). Using the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM), in 1979 and 1980 the principal surgical procedure and principal diagnosis were coded for each discharge in the sample. The MEDPAR file contained no information on secondary diagnoses or operations, although such information has been coded since 1984. The enrollment file maintains current entitlement information for all enrollees, including date of death. The records of hospital stays for the eight selected operations were linked to the enrollment file to identify all deaths, regardless of where the deaths occurred, for a 12-month period following surgery.

Discharges of aged beneficiaries occurring in 1979 and 1980 were pooled to increase sample size. Rehospitalizations for a study procedure were not excluded, i.e., if an individual underwent more than one study procedure during the period 1979-80, each procedure was included as a separate operation. All patients with a principal diagnosis of cancer for the stay in which the surgery was performed were excluded from the study. It was assumed that mortality rates for cancer patients would be determined, to a large extent, by their disease and would be less influenced by their operations per se. Four percent of all surgical discharges were excluded because of a principal diagnosis of cancer; this included 17 percent of prostatectomy discharges and 0.7 percent of all other discharges.[2]

Several limitations are present in the data. First, the exact date of death is not always identifiable because the date of death in the Medicare enrollment file is sometimes coded as the last day of the month of death. For this reason, the exact time between surgery and death had to be estimated. Assuming that dates of surgery are distributed uniformly throughout the month, we defined deaths within the first 1.5 months of surgery as those occurring in the month of surgery and the following month. [3] This included most deaths occurring in the hospital. Similarly, deaths within 2.5 months were defined as those occurring in the month of surgery and the following 2 months.

Secondly, there are known to be some problems with the reliability of diagnostic and surgical data in the Medicare Statistical System. The National Academy of Sciences' Institute of Medicine (IOM) (1977) compared Medicare diagnostic and surgical information with that obtained by a trained field team that reviewed medical records for a sample of hospital cases. Discrepancies were found for many diagnoses and procedures. In 21 percent of the cases reviewed, there was a discrepancy between the IOM abstract and the Medicare record. The 21-percent disagreement rate included disagreements about whether or not a procedure was performed and also about the nature of the principal procedure. In 43 percent of the cases in which Medicare records indicated a procedure was performed, there was a disagreement between the Medicare record and the IOM record. Most of the discrepancies were caused by incomplete narrative information on the Medicare claim form from which codes were assigned.

Other errors included routine misuse of the coding system and the improper designation of one of several procedures as the principal one. Some types of errors might result in some undercounting of certain operations, but these errors would not invalidate the information obtained for those cases identified for our study. Other types of errors are undoubtedly minor in nature and would also not invalidate the study (e.g., errors involving only the fourth digit of the surgical code). The IOM study did not reveal any errors that would appear to systematically bias our study results.

Because the study data constitute a 20-percent sample of discharges for selected procedures, there is sampling error associated with the estimates presented in the tables.[4]

Lastly, the study does not include Medicare disabled beneficiaries (under 65 years of age), who constitute approximately 10 percent of the Medicare population.

[2]For this study, certain consistency edits were performed to identify cases of miscoding. For example, out of 67,000 prostatectomy cases identified (including transurethral prostatectomies and others), 1,450 or 2 percent were identified as having been performed on women. These cases were excluded from the study.

[3]A fuller discussion is available in the Technical note, Table A.

[4]A fuller discussion of reliability of estimates and the estimated standard errors for selected tables is available from the authors.

Table 1
Average annual number of discharges per 10,000 aged Medicare enrollees for selected procedures, by age and sex: 1979-80

Procedure and sex	All ages	65-74 years	75-84 years	85 years or over
		Discharges per 10,000 enrollees		
Prostatectomy (TURP) (Male only)	121.3	105.9	151.1	142.8
Cholecystectomy	36.9	39.1	36.1	26.3
Male	32.5	32.6	33.6	26.7
Female	40.0	44.1	37.5	26.1
Inguinal hernia repair	34.7	35.9	35.7	24.2
Male	75.6	74.0	82.3	63.0
Female	7.0	6.2	8.4	7.6
Lens extraction	114.1	88.7	155.7	136.9
Male	102.2	82.5	139.1	134.0
Female	122.1	93.5	165.3	138.2
Femur fracture reduction	21.5	8.7	29.8	75.1
Male	11.4	5.6	16.7	43.1
Female	28.3	11.1	37.4	88.7
Coronary artery bypass	6.5	9.8	2.1	([1])
Male	11.3	15.8	3.8	([1])
Female	3.3	5.2	1.1	([1])
Hip arthroplasty (total replacement)	10.5	10.3	11.7	7.3
Male	8.9	9.0	9.6	5.0
Female	11.5	11.4	13.0	8.2
Hip arthroplasty (other)	18.8	9.0	26.6	55.2
Male	10.0	5.6	14.2	33.2
Female	24.8	11.6	33.9	64.5

[1]Data on coronary bypass for enrollees 85 years of age or over are excluded because of the small number of operations.
NOTE: Data exclude discharges with a principal diagnosis of cancer.
SOURCE: Health Care Financing Administration, Bureau of Data Management and Strategy: Data from the Medicare Statistical System.

Findings

Average annual numbers of discharges (noncancer related) per 10,000 aged enrollees for 1979-80, by age and sex, are presented in Table 1. Lens extraction and TURP were the most common procedures; lens extraction accounted for 114.1 discharges annually per 10,000 enrollees, and TURP accounted for 121.3 per 10,000 male enrollees. The next most common operations were cholecystectomy (36.9 discharges per 10,000 enrollees) and inguinal hernia repair (34.7 discharges per 10,000 enrollees). Coronary artery bypass was the least common of this group of procedures, with an annual average of 6.5 discharges per 10,000 aged enrollees during 1979-80. (The annual number of noncancer related discharges among aged enrollees for these procedures is given in the technical note, Table B.)

The majority of some of these operations are performed on Medicare beneficiaries. In the United States in 1979, 86 percent of hip arthroplasties (other), 76 percent of lens extractions, 74 percent of TURP's, 69 percent of femur fracture reductions, and 57 percent of hip arthroplasties (total hip replacements) were performed on people 65 years of age or over (National Center for Health Statistics, 1982). However, for cholecystectomy, inguinal hernia repair, and coronary bypass, between 23 and 28 percent of each procedure was performed on aged people.

Different incidence rates by age are evident for the various operations. The number of discharges per 10,000 enrollees for hip arthroplasty (other) and femur fracture reduction increased sharply with age, whereas the incidence of coronary artery bypass decreased (Table 1). These differences probably reflect both underlying patterns of morbidity and medical opinion about the advisability of doing certain operations at different ages. There are also marked differences in discharge rates between males and females, with males exhibiting higher rates at all ages for coronary bypass and hernia repair, whereas females exhibit higher rates for hip arthroplasty of both types and femur fracture reduction. This latter difference in rates is related to a higher incidence of hip fracture among aged females, which is, in turn, related to loss of bone mass (osteoporosis) with age (National Institutes of Health, 1984).

The average annual number of deaths occurring within the first 1.5 months following surgery is shown in Table 2. The largest number of deaths, 4,595 annually, occurred after femur fracture reduction. Among hip arthroplasty (other) patients, there were 3,435 deaths. Deaths following both operations were greatest among patients 85 years of age or over.

Among the eight procedures studied, deaths per 10,000 operations in the 1.5 months following surgery were highest following femur fracture reduction (878), hip arthroplasty (other) (750), and coronary artery bypass (615) (Table 3). Deaths among lens extraction patients were by far the least common, with only 49 per 10,000 operations. The death rate increased with age for all operations. For most operations, the death rate for males at all ages was greater than that for females at all ages, with the exception of coronary artery bypass at all ages and inguinal hernia repair among those 65-74 years of age. The difference in death rates by sex was especially large for femur

Table 2
Average annual number of deaths among aged Medicare enrollees in the 1.5 months following surgery for selected procedures, by age and sex: 1979-80

Procedure and sex	All ages	65-74 years	75-84 years	85 years or over
	Number of deaths			
Prostatectomy (TURP) (Male only)	2,553	798	1,138	618
Cholecystectomy	3,348	1,190	1,460	698
Male	1,490	630	590	270
Female	1,858	560	870	428
Inguinal hernia repair	1,025	303	475	248
Male	888	258	420	210
Female	138	45	55	38
Lens extraction	1,368	425	655	288
Male	658	233	303	123
Female	710	193	353	165
Femur fracture reduction	4,595	505	1,760	2,330
Male	1,543	210	630	703
Female	3,053	295	1,130	1,628
Coronary artery bypass	975	810	158	([1])
Male	563	480	78	([1])
Female	413	330	80	([1])
Hip arthroplasty (total replacement)	525	175	195	155
Male	198	83	80	35
Female	328	93	115	120
Hip arthroplasty (other)	3,435	453	1,378	1,605
Male	1,183	193	510	480
Female	2,253	260	868	1,125

[1]Data on coronary bypass for enrollees 85 years of age or over are excluded because of the small number of procedures.

NOTES: Data are from a 20-percent sample of Medicare hospital discharges. Counts have been multiplied by 5 to estimate totals. Data exclude discharges with a principal diagnosis of cancer.

SOURCE: Health Care Financing Administration, Bureau of Data Management and Strategy: Data from the Medicare Statistical System.

Table 3
Average annual number of deaths per 10,000 operations among aged Medicare enrollees within 1.5 months following surgery for selected procedures, by age and sex: 1979-80

Procedure and sex	All ages	65-74 years	75-84 years	85 years or over
	Deaths per 10,000 operations			
Prostatectomy (TURP) (Male only)	214	119	269	631
Cholecystectomy	372	210	534	1,157
Male	467	305	627	1,475
Female	320	156	486	1,019
Inguinal hernia repair	121	58	176	447
Male	120	55	182	487
Female	134	90	138	307
Lens extraction	49	33	56	92
Male	65	44	78	133
Female	40	25	45	74
Femur fracture reduction	878	401	781	1,354
Male	1,378	589	1,347	2,377
Female	742	327	632	1,142
Coronary artery bypass	615	571	975	([1])
Male	507	480	723	([1])
Female	868	788	1,475	([1])
Hip arthroplasty (total replacement)	206	117	219	931
Male	226	145	297	1,014
Female	195	100	186	909
Hip arthroplasty (other)	750	347	684	1,270
Male	1,205	541	1,283	2,112
Female	626	275	536	1,085

[1]Data on coronary artery bypass for enrollees 85 years of age or over are excluded because of the small number of procedures.

NOTE: Data exclude discharges with a principal diagnosis of cancer.

SOURCE: Health Care Financing Administration, Bureau of Data Management and Strategy: Data from the Medicare Statistical System.

fracture reduction, with males experiencing approximately twice the mortality of females in the 1.5 months following surgery. Higher in-hospital mortality rates for females undergoing coronary artery bypass surgery have been noted in two other studies (Fisher et al., 1982; and Douglas, et al., 1981), although both of these studies reported that the difference in mortality between males and females was not statistically significant for the group 60 years of age or over. Differences in coronary artery bypass mortality by sex may be related to the fact that females have smaller physical stature and smaller coronary arteries (Fisher et al., 1982).

The similarity in mortality rates between patients undergoing femur fracture reduction and those undergoing hip arthroplasty (other) is because of the high incidence of hip fracture among the latter group. Seventy-one percent of these patients had a principal diagnosis of femur fracture (data not shown in tables). Somewhat surprisingly, hip arthroplasty (other) patients without a principal diagnosis of femur fracture exhibited mortality patterns similar to patients with a fracture. It is possible that some of the patients without a principal diagnosis of femur fracture may have had that as a secondary diagnosis. (As noted earlier, only the principal diagnosis is recorded in the Medicare Statistical System).

Mortality rates for patients undergoing total hip replacement varied considerably according to whether a principal diagnosis of femur fracture was present (Table 4). For each age and sex group, patients with a fracture diagnosis exhibited considerably higher mortality rates than those with other diagnoses. Higher mortality rates for patients with a fracture may reflect the effects of the injury, as well as the fact that the surgery is less likely to be elective, and many cases may be poor surgical risks. In fact, those total hip replacement patients with a diagnosis of femur fracture exhibited mortality rates similar to patients undergoing femur fracture reduction and hip arthroplasty (other). This suggests that a fractured femur is a strong determinant of mortality, regardless of the procedure used to repair it.

Table 4

Deaths per 10,000 operations within 1.5 months of surgery among aged Medicare enrollees for patients undergoing total hip replacement, by diagnosis of fracture, sex, and age: 1979-80.

Sex and age	Percent of patients with principal diagnosis of fracture	Deaths per 10,000 operations: With principal diagnosis of fracture	Deaths per 10,000 operations: Without principal diagnosis of fracture
Total	9.3	821	143
65-74 years	5.1	396	102
75-84 years	11.5	809	143
85 years or over	35.9	1,381	679
Males	6.0	1,232	162
65-74 years	3.6	617	128
75-84 years	7.5	1,605	190
85 years or over	35.5	1,633	674
Females	11.0	704	133
65-74 years	6.0	315	87
75-84 years	13.2	612	121
85 years or over	36.0	1,316	680

NOTE: Data exclude discharges with a principal diagnosis of cancer.
SOURCE: Health Care Financing Administration, Bureau of Data Management and Strategy: Data from the Medicare Statistical System.

A diagnosis of femur fracture is much more frequent among the oldest arthroplasty (total replacement) patients (Table 4). Only 5.1 percent of those 65-74 years of age exhibited a principal diagnosis of femur fracture, whereas 35.9 percent of those 85 years of age or over showed this diagnosis. This explains why the mortality rate for total hip replacement patients rises so steeply with increasing age. Females were generally more likely to exhibit a diagnosis of femur fracture than males, although females' mortality rates for total hip replacement tended to be lower.

The age-specific and sex-specific mortality risk of the study group during the 1.5 months following surgery, relative to the experience of the Medicare aged population at large, is shown in Table 5. The comparisons are presented in the form of mortality ratios (MR), i.e., the ratio of observed deaths to those expected if the sample patients experienced the prevailing mortality pattern of the Medicare aged population. The expected mortality pattern is estimated by dividing Medicare deaths for 1979 and 1980 by the sum of Part A program enrollments (as of July 1 of both years), then prorating them by month (technical note, Table C).

Although observed mortality rates for specified procedures are compared with the prevailing mortality rate in the Medicare population, this should not be taken as an indication that post-surgical patients are truly "expected" to experience prevailing mortality rates. Because many surgical patients have poor underlying health, it is not known what their mortality patterns would be if the study procedures had not been performed. Consequently, MR's are not intended to measure avoidable mortality caused by surgery. They are, rather, presented as a descriptive measure that puts observed death rates into perspective. The use of MR's also facilitates comparisons between age and sex groups.

The highest MR's among the eight procedures studied are associated with coronary artery bypass, with an overall MR of 12.54 during the 1.5 months following surgery (Table 5). The MR's for females are much higher than those for males. In the group 65-74 years of age, which accounts for most of the bypass operations, males have MR's of 9.41 and females, 30.70. As discussed previously, higher mortality for females undergoing coronary artery bypass surgery is also reflected in the age-specific deaths per 10,000 operations (Table 3). Patients undergoing femur fracture reduction and hip arthroplasty (other) also had high MR's; for femur fracture reduction, MR's exceeded 9 for all groups except females 85 years of age or over, and for hip arthroplasty (other) the MR's were 8 or more for all age-sex groups except females over 85 years of age. MR's for lens extraction

Table 5
Mortality ratios in first 1.5 months following surgery for aged Medicare enrollees for selected procedures, by age and sex: 1979-80

Procedure and sex	All ages[1]	65-74 years	75-84 years	85 years or over
	Mortality ratios			
Prostatectomy (TURP) (Male only)	2.49	2.33	2.47	2.79
Cholecystectomy	6.30	6.04	6.63	6.12
Male	5.98	6.00	5.76	6.51
Female	6.59	6.10	7.39	5.90
Inguinal hernia repair	1.58	1.20	1.71	2.08
Male	1.51	1.08	1.67	2.15
Female	2.29	3.53	2.10	1.79
Lens extraction	.69	.92	.69	.49
Male	.73	.87	.71	.59
Female	.65	.99	.68	.43
Femur fracture reduction	8.79	12.24	10.45	7.44
Male	11.32	11.51	12.35	10.49
Female	7.90	12.83	9.62	6.62
Coronary artery bypass	12.54	13.12	10.33	([2])
Male	8.93	9.41	6.60	([2])
Female	27.97	30.70	22.86	([2])
Hip arthroplasty (total replacement)	3.43	3.33	2.79	5.08
Male	2.98	2.84	2.71	4.52
Female	3.76	3.94	2.82	5.27
Hip arthroplasty (other)	8.14	10.65	9.21	6.96
Male	10.46	10.55	11.79	9.32
Female	7.28	10.72	8.16	6.28

[1]Age adjusted by indirect method.
[2]Data on coronary bypass for enrollees 85 years or over are excluded because of the small number of procedures.

NOTE: Data exclude discharges with a principal diagnosis of cancer.

SOURCE: Health Care Financing Administration, Bureau of Data Management and Strategy: Data from the Medicare Statistical System.

patients were consistently less than 1, which reflects a variety of factors. Technical advances in the procedure have made lens extraction relatively nontraumatic, with only a brief hospital stay involved. It is also likely that only patients considered to be in relatively good overall health are selected for this particular procedure because it is highly elective.

Contrasting patterns in age-specific MR's are evident for some of the operations. For females, the MR's decrease sharply with age for femur fracture reduction and hip arthroplasty (other), whereas MR's are relatively steady for males. The MR for males with inguinal hernia repair increases with age—1.08 for males 65-74 years of age, 1.67 for males 75-84 years of age, and 2.15 for males 85 years of age or over. This most likely reflects the fact that the proportion of males with a principal diagnosis of obstructed hernia increases with age from 4.3 percent for males 65-75 to 14.9 percent for those 85 or over, and the mortality rate associated with these patients is considerably higher than for other patients (data not shown in tables). Higher mortality rates for patients with obstructed hernias probably reflect, in part, the fact that inguinal hernia repair for these patients is not elective surgery, and many may be poor surgical risks. MR's for lens extraction patients decreased with age for both sexes, perhaps reflecting that the selection process for the operation results in older patients being in better health relative to their age-sex cohorts than younger patients. Coronary artery bypass patients also exhibited a decreasing MR with age, from 13.12 for patients 65-74 years of age to 10.33 for patients 75-84 years of age. This may again reflect the selection process. The MR's for total hip replacement patients increased sharply in the oldest group for both males and females, reflecting the increase, by age, in the proportion of cases exhibiting a principal diagnosis of fracture. For cholecystectomy and TURP, MR's remained relatively stable across ages. Among all operations, males tended to have lower MR's than did females in the 65-74 years of age group and higher MR's in the 85 years of age or over group (with the exception of total hip replacement).

The cumulative percents of death following surgery, unadjusted for age and sex differences, for various time periods are shown in Table 6. Mortality after 12.5 months was highest for patients undergoing femur fracture reduction (23.9 percent), and hip arthroplasty (other) (21.1 percent), reflecting the higher age of this group, as well as the complications associated with a fractured femur. This high mortality rate is similar to that reported by Jensen and Tondevold (1979) for hip fracture patients, 26.8 percent after 1 year, and less than that reported by Beals (1972), 50 percent after 1 year, and Evans et al., (1979), 40 percent after 6 months. Lens extraction (5.3 percent), total hip replacement (5.9 percent), and inguinal hernia repair (6.4 percent) patients had the lowest mortality after 12.5 months.

Indirectly standardized MR's (adjusted for age and sex) for various time periods following surgery are presented in Table 7. For all operations except lens

Table 6
Unadjusted cumulative percent of deaths following surgery for aged Medicare enrollees, by type of procedure and time after operation: 1979-80

Procedure	Time after operation 1.5 months	3.5 months	6.5 months	12.5 months
	Percent			
Prostatectomy (TURP)	2.1	4.1	6.4	10.5
Cholecystectomy	3.7	5.2	6.7	9.1
Inguinal hernia repair	1.2	2.2	3.6	6.4
Lens extraction	.5	1.3	2.6	5.3
Femur fracture reduction	8.8	13.8	18.2	23.9
Coronary artery bypass	6.2	7.3	8.3	10.0
Hip arthroplasty (total replacement)	2.1	3.2	4.3	5.9
Hip arthroplasty (other)	7.5	12.3	16.0	21.1

NOTE: Data exclude discharges with a principal diagnosis of cancer.
SOURCE: Health Care Financing Administration, Bureau of Data Management and Strategy: Data from the Medicare Statistical System.

extraction, the indirectly standardized mortality ratio (ISMR) drops substantially after the first 1.5 months following surgery. The ISMR is highest for coronary artery bypass patients in the first 1.5 months (12.54), but declines very quickly thereafter, and is not significantly different from 1 after 3.5 months. Femur fracture reduction and hip arthroplasty (other) patients exhibit the highest ISMR's after the first 1.5 months and remain the highest throughout the rest of the first year.

The ISMR for TURP is not extremely high initially (2.49 in the first 1.5 months), but does not decline as rapidly as for other operations, stabilizing in the area of 1.3 to 1.4 after a few months. The ISMR for cholecystectomy also remains significantly above 1 for most of the year. After the first 1.5 months, the ISMR for inguinal hernia repair is not significantly different from 1.

Elevated ISMR's, over a several-months period, may be related to these patients' underlying poor health, which led to surgery in the first place, or the elevated ISMR's may be related to long-term complications following surgery. As mentioned earlier, the initial low MR for lens extraction patients probably reflects a favorable selection factor. Lens extraction operations are normally not performed on patients who are very ill, and the operation itself is generally not life-threatening. Consequently, lens extraction patients might be expected to have a lower mortality following surgery than the general Medicare population.

Total hip replacement patients exhibit a very unexpected pattern in that their ISMR is high initially (3.43 in the first 1.5 months and 1.41 between 2.5 and 3.5 months after surgery), but it drops significantly below 1 after approximately 6 months. The ISMR for these patients also remains substantially below 1 for the months 12.5 to 18.5 (data not shown in tables). We are not sure why total hip replacement patients should exhibit better than average mortality patterns at 6 months and more following surgery. It is possible that the operation itself acts as a screen, or selection process, that produces a surviving group of healthier than average patients. It is also possible that because total hip replacement is usually an elective procedure, the patient population is relatively healthy to begin with.

The rate of in-hospital deaths is compared with the rate in the 1.5 months following surgery in Table 8. The number of in-hospital deaths includes only those deaths that occurred during the hospital stay (regardless of its length) during which the operation was performed. A number of studies of post-surgical mortality have been limited to data on in-hospital deaths. This study indicates that such studies probably miss a substantial proportion of post-surgical deaths.

Table 7
Indirectly standardized (by age and sex) mortality ratios (MR's) for aged Medicare enrollees, by type of procedure and time after operation: 1979-80

Procedure	Total	Time after operation 0-1.5 months	1.5-2.5 months	2.5-3.5 months	3.5-6.5 months	6.5-9.5 months	9.5-12.5 months
				Mortality ratios			
Prostatectomy (TURP)	[1]1.47	[1]2.49	[1]1.85	[1]1.70	[1]1.43	[1]1.32	[1]1.34
Cholecystectomy	[1]1.86	[1]6.30	[1]2.47	[1]1.49	[1]1.42	[1]1.21	1.07
Inguinal hernia repair	1.00	[1]1.58	1.10	.90	.95	.96	.96
Lens extraction	[1].89	[1].69	[1].80	[1].84	[1].91	.97	1.04
Femur fracture reduction	[1]2.87	[1]8.78	[1]4.92	[1]3.79	[1]2.64	[1]1.98	[1]1.84
Coronary artery bypass	[1]2.44	[1]12.54	[1]2.18	[1]1.71	1.12	.79	1.03
Hip arthroplasty (total replacement)	[1]1.18	[1]3.43	[1]1.65	[1]1.41	.91	[1].74	[1].75
Hip arthroplasty (other)	[1]2.74	[1]8.13	[1]5.20	[1]3.60	[1]2.41	[1]1.91	[1]1.66

[1]$p < .05$, 2-sided test of MR = 1.

NOTE: Data exclude discharges with a principal diagnosis of cancer.

SOURCE: Health Care Financing Administration, Bureau of Data Management and Strategy: Data from the Medicare Statistical System.

In-hospital deaths as a percent of all deaths occurring within 1.5 months of surgery are shown in Table 8; the assumption used is that all in-hospital deaths occur within 1.5 months of surgery.[5] Only for coronary artery bypass did the rate of in-hospital deaths, as a percent of all deaths within 1.5 months following surgery, exceed 70 percent. For TURP and inguinal hernia repair, fewer than 50 percent of deaths during this time period occurred in the hospital. Lens extraction patients are excluded because of their low death rates and brief hospital stays.

Regional data (with region defined as region of patient residence) on age-adjusted and sex-adjusted mortality rates within 1.5 months of surgery are provided in Table 9. Lens extraction is excluded from the table because the mortality rate is very low. The West has the lowest mortality rate of all four regions for four of the seven procedures: TURP, femur fracture reduction, coronary artery bypass, and hip arthroplasty (other). These results are similar to Luft's (1980) findings, which showed generally lower rates of in-hospital post-surgical mortality in the West. For cholecystectomy, repair of inguinal hernia, and total hip replacement, the West has a mortality rate similar to that for the other regions.

Other regional variations in mortality rates are also evident. In particular, mortality following total hip replacement is almost twice as high in the South as in the Northeast. Mortality following inguinal hernia repair is also higher in the North Central region than elsewhere.

A possible explanation for the lower mortality rates in the West is that rates of surgery there are higher than the national average for some procedures. A high incidence of surgery could be associated with a higher number of low-risk patients (not explained by age or sex differences) undergoing these operations, which would lead to a lower mortality rate. Roos and Roos (1981) examined this issue for hospital stays in Manitoba and concluded that the proportion of high-risk patients in their study did not vary between areas with high and low surgery rates.

To examine the possible relationship between surgery rates and mortality, a Spearman's rank correlation coefficient was computed for the regional mortality rates and age- and sex-adjusted surgery rates (Technical note, Table D). In order to make mortality and surgery rates comparable across procedures, each procedure-specific regional mortality rate was first divided by the U.S. mortality rate for that procedure. The procedure-specific regional surgery rates were treated in a similar fashion. The regional rates were then pooled across procedures, yielding 28 pairs of mortality and surgery rates. The correlation coeffi-

[5]Of all in-hospital deaths following the study procedures, between 90 and 95 percent occurred in the month of surgery or the following month.

Table 8
Average annual number of deaths per 10,000 operations in the hospital compared with the number occurring within 1.5 months following surgery, by type of procedure: 1979-80

Procedure	Deaths per 10,000 operations		In-hospital as a percent of within 1.5 months[1]
	In-hospital	Within 1.5 months	
Prostatectomy (TURP)	87	214	41
Cholecystectomy	253	372	68
Inguinal hernia repair	51	121	42
Femur fracture reduction	504	878	57
Coronary artery bypass	475	615	77
Hip arthroplasty (total replacement)	116	206	56
Hip arthroplasty (other)	416	750	55

[1]The deaths expressed in the numerator are not entirely contained in the denuminator because 5-10 percent of in-hospital deaths occur later than 1.5 months following surgery.

NOTE: Data exclude discharges with a principal diagnosis of cancer.

SOURCE: Health Care Financing Administration, Bureau of Data Management and Strategy: Data from the Medicare Statistical System.

Table 9
Age- and sex-adjusted deaths per 10,000 operations within 1.5 months following surgery, by region and type of procedure: 1979-80[1]

Procedure	United States	Deaths per 10,000 operations				Ratio of region to the United States			
		Northeast	North-Central	South	West	Northeast	North-Central	South	West
Prostatectomy (TURP)	214	231	216	216	185	1.08	1.01	1.01	.86
Cholecystectomy	372	373	355	384	376	1.00	.95	1.03	1.01
Inguinal hernia repair (Male only)	120	114	140	108	112	.95	1.17	.90	.93
Femur fracture reduction	878	940	893	892	738	1.07	1.02	1.02	[2].84
Coronary artery bypass (Under 85 years of age only)	612	689	692	583	504	1.13	1.13	.95	.82
Hip arthroplasty (total replacement)	206	141	186	274	225	.68	.90	[2]1.33	1.09
Hip arthroplasty (other)	750	759	786	769	636	1.01	1.05	1.03	[2].85

[1]Age = and sex-adjusted to the U.S. population by the direct method.
[2]P<.0125, two-sided test of ratio ≠1.

cient for these data was -.11, which did not achieve statistical significance. Thus, there is no evidence that low mortality is systematically associated with high surgery rates on a regional basis across procedures. It is possible, however, that mortality and surgery rates may be related for individual procedures. For example, the surgery rate for coronary artery bypass is much higher in the West than elsewhere (10.8 per 10,000 in the West for the 65-84 years of age population versus 7.2 per 10,000 nationally), and the mortality rate there is much lower.

Conclusions

The high mortality rates associated with several study procedures indicate that considerable risk is involved when certain operations are performed on the aged, particularly on the very old. Over 6 percent of the coronary artery bypass patients died within 6 weeks of surgery, and approximately 8.8 percent of the patients undergoing femur fracture reduction died within the same time period. Hospital use and mortality associated with femur fracture reduction and, to a large extent, hip arthroplasty (other), reflect the widespread problem of osteoporosis among the aged, particularly females. This condition causes the bones to lose mass and become brittle, making them more susceptible to fracture. Often an osteoporotic patient will suffer a fractured hip following a fall in the home or elsewhere. The high mortality rate following femur fracture reduction, as well as hip arthroplasty (other) in the presence of fracture, indicates how serious the problem of osteoporosis is among the aged. To the extent that the rate of bone mass loss can be slowed (by diet, exercise, or drugs) and the risk of falls lowered, hospitalizations and mortality among the aged might be reduced (National Institutes of Health, 1984).

Coronary artery bypass surgery recently came under scrutiny in the Coronary Artery Surgery Study (CASS) sponsored by the National Heart, Lung, and Blood Institute and conducted during 1974-79. Reporting on that study, Gersh et al. (1983) noted a perioperative (within 30 days) mortality rate of 5.2 percent for patients over 65 years of age, which is in line with the Medicare mortality rate of 6.15 percent within 1.5 months of surgery reported previously. The 5.2 percent perioperative mortality rate reported by Gersh et al. was significantly higher than the 1.9 percent mortality experienced by the CASS population under 65 years of age. Gersh et al. also reported a trend toward increased mortality with age for the population over 65 years of age, which is also a finding of our study (cited earlier). Chassin et al. (1985) report an overall perioperative mortality rate of 2.7 percent (based on a literature review of several different studies), which is a substantially lower rate than that exhibited by the Medicare population over 65 years of age. Chassin et al. also report a composite perioperative mortality rate of 6.5 percent for patients over 69 years of age. In a separate series of reports (Coronary Artery Surgery Study, 1983a and b), the CASS investigators concluded, on the basis of a randomized trial, that coronary artery bypass surgery does not increase life expectancy when compared with medical treatment for certain patients under 65 years of age with moderate levels of stable angina; however, some evidence was presented that quality of life is improved by the surgery compared with medication only. Other controlled trials have shown that certain high-risk patients have better long-term survival with coronary artery bypass surgery (European Coronary Surgery Study Group, 1982; and Veterans' Administration Coronary Artery Bypass Surgery Cooperative Study Group, 1984). Because the controlled trials, with the exception of the Veterans' Administration study, did not include aged patients, the high mortality reported for the aged in this and other studies raises the question of whether coronary artery bypass for the aged has comparable benefits in longevity.

For some study procedures, higher than average mortality rates persisted for many months after surgery for all age groups. In particular, mortality rates associated with TURP, cholecystectomy, hip arthroplasty (other), and femur fracture reduction remained higher than the rates in the overall Medicare population for a full year following surgery. It is not known how these patients would have fared without surgery, nor are the outcomes known for Medicare patients who forego these operations when faced with the choice. (In the case of femur fracture reduction and hip arthroplasty [other], the procedures are generally not elective.) The persistence of higher than average mortality rates suggests investigation into other unfavorable outcomes that follow surgery. We plan to study rehospitalizations after surgery for the procedures examined in this study.

The mortality rates were the highest for all procedures for the oldest group (85 years of age or over), e.g., in the first 1.5 months, 6.3 percent for TURP patients and 11.6 percent for cholecystectomy patients. The fact that mortality rates increase sharply with age raises the question of whether certain elective procedures should be performed at younger ages if it appears that surgery may eventually be necessary. Wennberg et al. (1980) address this issue for cholecystectomy for silent gallstones and prostatectomy for prostatic hypertrophy; Fitzpatrick et al. (1977) also explore this dilemma in the case of cholecystectomy for silent gallstones. They point out that surgery performed at younger ages, when symptoms are minimal, will produce less risk than surgery done later as an emergency. On the other hand, elective surgery does present significant risk, and the patient's symptoms may not worsen over time, or the patient may die of other causes in the meantime. Although conclusive answers on these issues must come from more detailed clinical studies, the information on numbers of deaths and age-specific mortality rates contained in this study may suggest areas for further research.

The large number of post-surgical deaths after discharge from the hospital suggests that studies of post-surgical mortality that are limited to in-hospital deaths may be underestimating the risks of surgery or of the conditions leading to surgery. Clearly, studies of surgical outcomes should follow patients for a few months after surgery, with the length of time depending on the procedure.

Age-adjusted and sex-adjusted mortality rates were lower in the West than elsewhere for most study procedures. We found no obvious explanation for this phenomenon. We examined the hypothesis that enrollees in the West may undergo surgery more often than elsewhere, and that therefore hospitals in the West may operate on more low-risk patients, with lower mortality rates as a result. We concluded that the data do not exhibit any systematic relationship between mortality rates and surgery rates across regions for these study procedures, although a relationship may hold for individual operations. More research needs to be done in this area to determine if patterns of medical practice, criteria for patient selection, or differences in patient risk factors are responsible for the better mortality experience in the West.

The kind of data presented in this article should be useful to other researchers for several purposes. For example, the data can provide a baseline for comparison with data describing local experiences. Mortality statistics similar to those in this article can also be monitored over time, either nationally or locally, to help assess the impact of new technologies and procedures. Many operations are developed and evaluated largely on the population under 65 years of age. But these operations are then performed at an increasing rate on older patients as physician experience grows and operative techniques are perfected. Data such as these can monitor the outcomes among the aged of such procedures (e.g., coronary artery bypass surgery). Additionally, because these data represent the total national experience of the aged, they supplement data from clinical trials and prospective studies, which often are based in major medical centers that may have better than average outcomes. Thus these data can monitor the outcome experience of new procedures as they diffuse from leading medical centers into other hospitals.

Data such as these can be used to help evaluate the impact on quality of changes in the organization and financing of medical care. For example, secular trends in mortality can provide insights into the impact of Medicare's new prospective payment system for hospitals.

The quality and completeness of Medicare diagnostic and procedure data are expected to improve. Since 1984, HCFA has been collecting data on up to five diagnoses and three surgical procedures per stay on 100 percent of all hospitals stays. Data quality will be monitored carefully because, under prospective payment, diagnostic and surgical data will be the most important single items in determining payments to hospitals. Thus, the usefulness of the kind of data this article presents should be enhanced.

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Technical note

In an effort to verify the accuracy of the observed number of deaths occurring within 1.5 months of surgery, age-specific and sex-specific MR's were recalculated for patients undergoing surgery between the 10th and 20th of the month for femur fracture reduction and coronary artery bypass. By restricting this subsample to surgeries performed in the middle of the month, measurement error in identifying the number of deaths that occured within 6 weeks of surgery is reduced. The MR's for these cases were then compared with those calculated on the basis of the entire sample. As shown in Table 10, agreement between the two groups is quite good, with less than a 10-percent difference in most cases. As expected, the MR's for the larger cells tend to agree more closely than those for the smaller cells.

Lastly, the distribution of surgeries over days of the month was examined to determine if more surgeries tend to occur early or late in the month. If such a tendency exists, the number of deaths occurring within the same month as surgery or the subsequent month could systematically overestimate (or underestimate) the number of deaths occurring within 6 weeks of surgery. The number of operations performed on days 1-10 (pooled across procedures) was compared with those performed on days 21-30, with an appropriate adjustment to account for February's fewer days. A total of 92,389 operations were performed on days 1-10, whereas 89,811 (adjusted) were performed on days 21-30. Although the difference is statistically significant ($p < .001$), the numbers of procedures are close enough so that any substantial impact on mortality statistics is unlikely. The slightly skewed distribution of surgeries during the month would tend to positively bias the estimates of observed deaths in the first 6 weeks. This bias would be offset to some extent: Because of the rapid decline in death rates following surgery, more deaths will tend to be missed in weeks 5-6 than will be incorrectly counted from weeks 7-8.

Table A
Comparison of mortality ratios computed for surgeries performed between the 10th and 20th of the month with those for the entire sample

Age and sex	Femur fracture reduction: Entire sample	Femur fracture reduction: 10-20th of month	Coronary artery bypass: Entire sample	Coronary artery bypass: 10-20th of month
	Mortality ratios			
Total	8.80	9.19	12.58	12.38
Male	11.36	11.33	8.96	9.29
Female	7.90	8.45	27.97	25.65
65-74 years	12.32	14.43	13.17	12.14
Male	11.67	12.50	9.46	9.15
Female	12.83	16.06	30.70	27.50
75-84 years	10.45	11.20	10.33	13.04
Male	12.35	11.92	6.60	9.41
Female	9.62	10.91	22.86	23.33
85 years or over	7.45	7.35	([1])	([1])
Male	10.52	10.53	([1])	([1])
Female	6.62	6.50	([1])	([1])

[1]Data on coronary artery bypass for enrollees 85 years of age or over are excluded because of the small number of procedures.

Table C
Expected deaths per 10,000 enrollees among the Medicare population for a 1.5-month period, by sex and age: 1979-80

Sex and age	Expected deaths per 10,000 per 1.5-month period
All persons	65.2
65-74 years	36.7
75-84 years	81.7
85 years or over	188.8
Male	79.8
65-74 years	50.9
75-84 years	108.9
85 years or over	226.3
Female	55.2
65-74 years	25.6
75-84 years	65.7
85 years or over	172.7

SOURCE: Health Care Financing Administration, Bureau of Data Management and Strategy: Data from the Medicare Statistical System.

Table B
Average annual number of discharges among aged Medicare enrollees for selected procedures, by age and sex: 1979-80

Procedure and sex	ICD-9-CM[1] codes	All ages	65-74 years	75-84 years	85 years or over
		Number of discharges			
Prostatectomy (TURP) (Male only)	60.2	119,308	67,213	42,308	9,788
Cholecystectomy	51.2	89,898	56,550	27,320	6,028
Male		31,913	20,675	9,408	1,830
Female		57,985	35,875	17,912	4,198
Inguinal hernia repair	53.0,53.1	84,525	51,968	27,020	5,538
Male		74,298	46,953	23,030	4,315
Female		10,228	5,015	3,990	1,223
Lens extraction	13.1-13.6,	277,678	128,355	117,938	31,385
Male	13.71	100,498	52,373	38,943	9,183
Female		117,180	75,983	78,995	22,203
Femur fracture reduction	79.05, 79.15	52,335	12,580	22,550	17,205
Male	79.25, 79.35	11,198	3,565	4,678	2,955
Female		41,138	9,015	17,873	14,250
Coronary artery bypass	36.1	15,845	14,195	1,615	(Less
Male		11,093	10,008	1,073	than
Female		4,753	4,188	543	60)
Hip arthroplasty (total replacement)	81.5	25,470	14,910	8,895	1,665
Male		8,728	5,685	2,698	345
Female		16,743	9,225	6,198	1,320
Hip arthroplasty (other)	81.6	45,820	13,028	20,150	12,643
Male		9,808	3,560	3,975	2,273
Female		36,013	9,468	16,175	10,370

[1]*International Classification of Diseases, Ninth Revision, Clinical Modification.*

NOTES: Data are from a 20-percent sample of Medicare hospital discharges. Counts have been multiplied by 5 to estimate totals. Data exclude discharges with a principal diagnosis of cancer.

SOURCE: *Health Care Financing Administration, Bureau of Data Management and Strategy: Data from the Medicare Statistical System.*

Table D
Average annual age-adjusted and sex-adjusted number of procedures per 10,000 aged Medicare enrollees, by region: 1979-80[1]

Procedure	United States	Region			
		Northeast	North-Central	South	West
	Number per 10,000 enrollees				
Prostatectomy (TURP)	121.3	114.0	125.6	119.2	128.7
Cholecystectomy	36.9	33.2	39.4	38.9	34.9
Inguinal hernia repair (Male only)	75.6	75.0	76.9	73.3	78.7
Femur fracture reduction	21.5	19.0	22.5	22.9	20.9
Coronary artery bypass (Under 85 years only)	7.2	4.9	7.6	6.6	10.8
Hip arthroplasty (total replacement)	10.5	9.3	13.0	7.2	14.5
Hip arthroplasty (other)	18.8	14.1	19.6	22.1	18.4

[1]Age adjusted and sex adjusted to the U.S. population by the direct method.

NOTE: Data exclude discharges with a principal diagnosis of cancer.

SOURCE: Health Care Financing Administration, Bureau of Data Management and Strategy: Data from the Medicare Statistical System.

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