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Effects of surgery on the mental status of older persons. A meta-analytic review

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Abstract

The data bases of 18 empirical studies were combined into one comprehensive data set and subjected to meta-analysis. The following trends were observed: (1) surgery has a significantly decompensating impact on the mental status of older persons, and the average effect size observed is modest (r = .37); (2) for all mental status measures included in the review (cognition, delirium and affect), effect size appears to be significantly moderated by patient age; (3) patient sex may be predictive of the kind of mental impairment that is most likely to occur within an older surgery population, with women manifesting a greater affinity for delirious and men for cognitive decompensation; (4) most existing research within this domain of study is either purely descriptive or anecdotal: of 46 studies reviewed, only 18, or 39.1% of the total published output, were of sufficient methodologic rigor to allow for scientifically valid effect-size computations. The implications of these findings for future research are discussed. (*J Geriatr Psychiatry Neurol* 1990;3:184–191).

The issue of the psychological effects of surgery on older persons has been the object of much conjecture but only limited systematic inquiry. The increased use of surgery as a routine health care practice with persons of advanced age has led to heightened speculation about such phenomena as postsurgical dementia and postoperative delirium within this patient constituency. However, such clinical inferences are frequently derived from small and nonrepresentative samples. The purpose of this paper is to clarify the current status of scientific knowledge in this field by means of a meta-analytic review of existing studies. Meta-analysis is a relatively new retrieval method that combines existing data sets into one summary file, and by so doing, often creates a critical mass of empirical information that allows for scientific deductions not attainable through any one of the individual studies included in the review. This particular endeavor will limit itself to an exploration of the effects of surgery (ie, the operative treatment of illness or disease) on the mental status of geriatric patients, ie, persons who are 65 years of age or older. As such, a relatively large body of research on strictly biomedical and biophysiologic outcomes of geriatric surgery has purposely been kept outside the purview of this particular meta-analysis.

Potentially relevant studies were traced through a computer search of the data bases available in *Index Medicus, Psychological Abstracts, Social Work Abstracts,* and *Dissertation Abstracts International.* It generated a total of 46 titles.[1-46] As meta-analysis is a method of quantitative summation that requires validly derived empirical data bases and research designs of an inferential nature, 22 studies had to be excluded as yielding only descriptive data allowing for no inferences about surgery effects.[1-22] Another six publications had to be omitted as containing only anecdotal information.[23-28] This left 18 studies of an inferential nature for the intended meta-analysis.[29-46] It will be clear that the studies omitted from this quantitative synthesis continue to be useful informational sources for clinical judgments and/or research hypotheses, but they lack the scientific rigor necessary for meta-analytic manipulation.

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Design Parameters Existing Research

As indicated, only 18 of the 46 studies (39.1%) dealing with the effects of geriatric surgery on patient mental status were of an inferential nature. A more detailed analysis of the design parameters of these 18 studies is provided in Tables 1 and 2. The age range represented by the geriatric surgery patients involved in these studies is from 59 to 86 years. Exactly half of the studies (50.0%) reported subject outcomes across more than one type of surgical operations, and of the studies being based on single surgical interventions, arthroplasties (22.2%), cholecystectomies (11.1%), and herniorrhaphies (11.1%) were the most frequently studied forms of surgery. As for the anesthetic procedures used in these surgical interventions, half the studies (50.0%) reported general anesthesia, 35.8% used a mix of anesthetic procedures, while local and spinal anesthesias were each reported by 7.1% of the studies reviewed. With regard to the research designs employed, the majority of studies undertaken (55.6%) used a simple posttest design (postoperative assessment only of patient mental status), while 22.2% were of the single group, pretest-posttest design. An identical proportion (22.2%) used a two-group, pretest-posttest methodology, the latter being the only one that begins to approach the design requirements of an experimental study. Random selection of subjects within surgery types was undertaken by slightly more than one third of the studies reviewed (38.9%). As for the timing of the postoperative assessments of mental status, the first such measure was taken at a mean time of 1.8 weeks postoperatively. For the five studies that provided for multiple postsurgical measurements, none reported more than two such assessments, the second of which was administered at an average time of 6.2 months after surgery.

TABLE 1
Descriptive Patient and Surgery Characteristics in 18 Studies Reviewed

Variable	Statistics*
Age, yr	Mean, 70; range, 59–86
Sex, % male	55.5
Married, %	62.7
Education	Mode, some high school
Race, % nonwhite	1.5
Type of surgery	
Arthroplasty	22.2
Cholecystectomy	11.1
Herniorrhaphy	11.1
Other (single)	5.6
Mixed	50.0
Type of anesthesia	
General	50.0
Spinal	7.1
Local	7.1
Mixed	35.8
Urgency	
Elective	50.0
Emergency	7.1
Mixed	35.8
Hospital stay, d	Mean, 13.7

*Percentages exclude missing data.

TABLE 2
Study Design Attributes of 18 Studies Reviewed

Variable	Statistics
Year of publication	Median, 1982; range, 1955–1988
Study design, %	
1 group, posttest only	44.4
1 group, pre- and posttests	22.2
2 groups, posttest only	11.2
2 groups, pre- and posttests	22.2
Comparison group, %	33.3
Random selection, %	38.9
Treatment group n	Mean, 336.5; median, 65
Comparison group n	Mean, 27.4; median, 26
Sample attrition, %	4.5
Posttest 1, wk*	Mean, 1.8
Posttest 2, mo*	Mean, 6.2

*Posttests indicate time to first and second postsurgical dependent variable (mental status) measurement.

If one considers that the design characteristics described here pertain to the most rigorous studies currently extant within this domain of inquiry, the outcomes obtained are not altogether assuring: only one third of the studies used control or comparison groups to gauge intervention effects (33.3%) and no fewer than 78.8% of them used research methodologies that have to be characterized as preexperimental, ie, they have design characteristics that constitute real threats to the internal validity of the research outcomes cited. This caveat should be kept in mind when, in subsequent pages, actual treatment effects will be discussed.

Main Effects

In this study, the pivotal outcome is the actual effect that surgery had on patient mental status as measured through standardized tests of mental status or observational procedures. The relevant data points on that score, recorded by each of the 18 studies reviewed here, were combined into one aggregate data file and subjected to multiple analyses.

Because the effects reported by the 18 individual studies varied in terms of the decisional test statistics used (eg, t, F, χ^2), it was necessary to convert these into one common metric. To that end, the r-index was chosen as the most appropriate measure of effect size (ES). It effectively transforms these various statistics into Pearson r's by means of established meta-analytic procedures.[47] It is a standardized, scale-invariant measure of ES, and hence, allows for meaningful comparisons across individual studies. It should be noted here that ES calculation was based on each individual study's critical comparison paradigm, be it a between-group or a within-group design. For studies without a comparison group or pretest measure (eg, one-group, posttest only designs), ES was calculated by comparing the individual study outcome to the estimated proportion of the individuals 65 years of age and over within the general population of elders expected to suffer signs or symptoms of mental decompensation without having undergone surgery (5%). The correlations, so obtained, are enumerated in Table 3.

The maximum r obtained in any one of the individual studies was .68; the lowest, .00. The summary statistics of Table 3 facilitate the interpretation of these achieved correlations across all 18 studies. It will be seen that, at posttest 1, the average r obtained was .37 and, for those studies with multiple postoperative measurements of mental status, it was reduced to .18 at posttest 2, suggesting an amelioration of ES with progression of postoperative time. The table also lists the 95% confidence interval around ES (.27 and .47), which indicates that the effects of surgery on patient mental status deviates significantly from 0. Further, using the Cohen convention for interpreting these correlational outcomes[48] the mean r of .37 across studies suggests that the surgery effect observed is to be classified as medium-sized. What does an ES of this magnitude mean in terms of scores on mental status instruments? On the average, postsurgical geriatric patients scored nearly one standard deviation (0.8) lower on indices of mental functioning than did the presurgical groups, or 78.8% of the posttest scores were lower than the average pretest scores. There is another important summary statistic listed in Table 3: the mean r^2. This metric is an indicator of the amount of variance in the mental status scores accounted for by the treatment factor (surgery). In posttest 1, only 14% of all variance was accounted for by the latter variable, and at posttest 2, it had reduced to 3% of total variance. These results suggest that the variation in subject mental status, as observed in these studies, was also influenced by factors other than surgery, as would of course be expected.

In order to produce one comprehensive test of the null hypothesis that surgery does not affect mental status significantly, a combined probability test was performed on the various decision statistics reported in the single studies. In accordance with the Stouffer combined test procedure,[49] the P-values cited in these studies were converted into their associated z-scores; they were then added and divided by the square root of n (number of studies). The results are listed in Table 4.

TABLE 3
R-Index of Treatment (Surgery) Effects in 18 Studies

Source	R-Index	
	Posttest 1	Posttest 2
Abram & Gill[29]	0.0	.58
Barnes[30]	—	.02
Bedford[31]	.44	—
Blundell[32]	.31	—
Chung *et al*[33]	.62	—
Deysine *et al*[34]	.63	—
Gilberstadt *et al*[35]	.17	—
Herron *et al*[36]	.68	—
Hole *et al*[37]	.30	—
Knox[38]	0.0	0.0
McCardle[39]	.05	—
Mezey[40]	.30	—
Millar[41]	.41	.18
Miller *et al*[42]	.30 and .52*	—
Phillips *et al*[43]	.64	—
Roos & Danziger[44]	—	.14
Seymour & Pringle[45]	.49	—
Simpson & Kellett[46]	.39	—
Summary statistics		
Maximum r	.68	.58
Minimum r	.00	.00
Median r	.39	.14
Mean r	.37	.18
95% confidence interval (r)	(.27, .47)	(−.02, .38)
Mean r^2	.14	.03

*This study reported outcomes on both cognition (r = .30) and delirium (r = .52).

TABLE 4
Additional Metastatistics on Effects of Surgery on the Mental Status of Elderly Patients

Metastatistics	Postsurgical Time	
	Posttest 1	Posttest 2
Combined Probability (additive z scores)	6.28*	3.21†
Homogeneity ES Analysis (χ^2)	32.68‡	18.73†

*$P < .001$.
†$P < .01$.
‡$P < .005$.

At posttest 1, the combined z-score was 6.28, while at posttest 2 it decreased to 3.28. However, both values carried P-values that were highly significant, implying that surgery had a real impact on the mental status of older patients, and thus, that the null hypothesis of no treatment effect has to be rejected. Moreover, it should be noted here that the achieved z-scores are positively signed, which means that the direction of the treatment effect (surgery) is in the nature of mental status decline or impairment.

Table 4 summarizes the statistics resulting from a formal test of homogeneity of outcomes between studies, yielding for both posttests 1 and 2 statistically signficant χ^2s (32.68 and 18.73, respectively). This test compares the actual variations in outcomes between studies to those expected on the basis of *sampling error* only: significant χ^2s allow for the deduction that the sample subjects in these studies cannot possibly have come from the same population. Thus, having actually found significant *heterogeneity* among the outcomes of the 18 studies involved in this analysis indicates that we must now try to identify the factors or variables that account for these differences and that we have to extend our search beyond the main effects just cited.

TABLE 5
Assessment Instruments of Mental Status Used in 18 Studies Reviewed

Mental Status Domain	N*	%	Assessment Instruments
Dementia† (cognition/ memory/ learning)	7	36.8	Wechsler Adult Intelligence Scale Wechsler Memory Scale Raven Progressive Matrices Pathway Test (A + B) Rey Auditory-Verbal Learning Pegboard Test Star Test
Delirium‡ (confusion/ clouding of consciousness)	7	36.8	Mini-Mental State Examination Geriatric Mental Status Exam Saskatoon Delirium Checklist Critical Flicker Fusion Test
Psychiatric problems§ (affect)	5	26.4	MMPI (D-Scale) CES (D-Scale)

*Ns total 19 because one study reported outcomes in both the dementia and delirium domains.
†37.5% of this domain was assessed by subjective clinician observation of patient behavior.
‡33.3% of this domain was assessed by subjective clinician observation of patient behavior.
§60.0% of this domain was assessed by subjective clinician observation of patient behavior.

Moderator Effects

The 18 studies in this meta-analytic review reported a wide variety of assessment instruments for the measurement of mental status among the geriatric surgery patients involved. They are listed in Table 5. As can be seen, they tapped the following domains of mental status: (1) cognition/memory/dementia, (2) delirium, and (3) psychiatric problems/affective symptomatology.

Because of the significant heterogeneity of variance among the outcome measures reported by the 18 studies, a moderator effect analysis was required; it was performed according to established meta-analytic procedures.[50] This analysis tested the relationships between the coded patient, surgery, and study characteristics listed in Tables 1 and 2 on the one hand and ES on the other. In each instance, ES was the dependent measure. Table 6 displays the results obtained in this moderator effect analysis.

For all psychological status measures combined, a statistically significant age effect was found, in the sense that surgery's impact on patient mental status is apt to increase, ie, to become more severe, with patient age. The significant F-ratios reported in Table 6 together with the associated r-indices reveal that mental decompensation due to surgery becomes evident particularly in the cohort of patients aged 71 years and older ($r = .47$; $F = 3.94$; $P < .05$), while it registers as nonexistent in the 60-years-or-younger age group. The zero-order correlation between the ES values reported and the average age of the patient samples studied was found to be .55 ($P < .05$). Thus, age appears to be a crucial factor in postsurgical mental decline.

Moderator effect analysis was also performed on the outcome measures within each *specific* domain of mental functioning. As Table 6 indicates, only one significant moderator effect was identified. Sex was found to be significantly related to the phenomenon of postsurgical dementia or cognitive decline: in those subject groups in which the proportion of males was in excess of 40% of the total sample size, the r-index observed was more than 20 times as large as that in groups with a lower proportion of males ($r = .43$ v $r = .02$; $F = 12.06$, $P < .05$). Furthermore, the zero-order correlation between the ES values obtained on all cognitive measures and the

TABLE 6
Results of Moderator Effect Analysis of Treatment (Surgery) Effects on the Mental Status of Elderly Patients

Domains of Mental Functioning	Moderator Variables		
All mental status measures	Age, yr		
$F(1,14) = 6.17$; $P < .05$	≤70	≥71	—
R-index	.22	.47	—
No. of studies	6	10	—
$F(2,13) = 3.94$; $P < .05$	≤60	61–70	≥71
R-index	.00	.26	.47
No. of studies	1	5	10
Correlation ES × patient age	$r(14) = .55$; $P < .05$		
All cognitive measures	Sex, % male		
$F(1,4) = 12.06$; $P < .05$	≤40	≥41	
R-index	.02	.43	
No. of studies	2	4	
Correlation ES × % males in sample	$r(4) = .87$; $P < .05$		
All delirium measures	No significant moderator effects		
All psychiatric measures	No significant moderator effects		

ES = effect size.

percentage of males in the patient samples studied was .87 ($P < .05$). These findings imply that there may be a sex difference in postsurgical cognitive decompensation: older females may be more surgery-resistant on this score than their male counterparts. The results of Table 6 further indicate that no statistically significant moderator effects could be found either for postsurgical delirium or for psychiatric-affective status changes in the postoperative period. In other words, the incidence of these latter forms of mental decompensation appear to be rather evenly distributed over the total patient pool, without a tendency to cluster in identifiable subsets of patients. Specifically, this moderator effect analysis found no significant effects for the following variables included in that analysis: patient race, education, and marital status, type of surgery, and type of anesthesia.

Additional Findings

The moderator effect analysis also yielded two significant interaction effects between kind or type of postoperative decline and (1) time after surgery and (2) patient sex.

From the data trend plotted in Figure 1, one can observe that cognitive decline, when it occurs, is apt to become more severe with progression of time, while conversely, delirious symptomatology tends to be most pronounced in the immediate postoperative period but then ameliorates with time ($F = 4.75$, $P < .05$). From a medicosurgical perspective, the latter phenomenon may be in accordance with clinical expectation.

The results in Figure 1 also indicate that postsurgical delirious and cognitive decompensation interact with sex. When comparing male-dominated patient groups with those containing fewer males (40% or less *v* 41% or more), delirious symptomatology declines with increasing male representation among elderly surgery patients, while, in contrast, cognitive impairment increases ($F = 6.04$, $P < .05$). This finding carries an implicit suggestion that elderly females, if they decompensate mentally as a function of surgery, are apt to do so more readily by a clouding of consciousness and related delirious

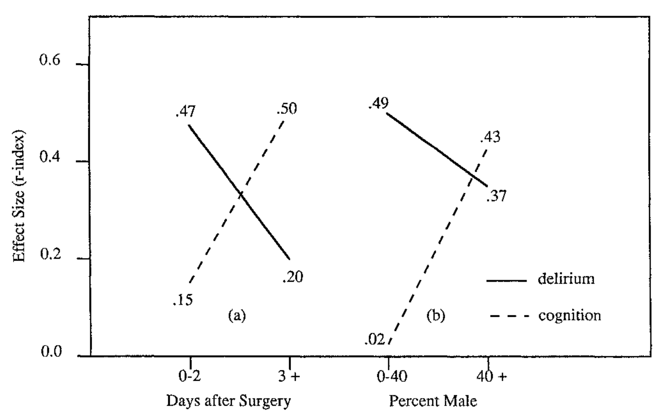

FIGURE 1
Significant interaction effects for cognitive and delirious postsurgical decompensation in older patients. **(a)** shows the interaction of type of symptom with days after surgery. **(b)** shows the interaction of type of symptom with sex of patient.

symptoms than by an impairment of cognitive functions. For males, the reverse is likely to be true.

Second, meta-analytic studies are often criticized as unreliable on grounds that published research on which they draw is biased in favor of significant findings (treatment effects), the argument being that nonsignificant outcomes are rarely published and remain inaccessible manuscripts in the file drawers of their original researchers. Rosenthal[51] has addressed that criticism by the development of a meta-analytic statistic called the *fail-safe N* (N_{fs}). It was calculated for these findings and is reported in Table 7. The calculated N_{fs} was 213 for posttest 1 and 17 for posttest 2. Applying the Rosenthal criterion measure of $(5 \times N) + 10$, in which N equals the number of studies actually included in the meta-analysis, one gets criterion values of $N_1 = 95$ and $N_2 = 35$ at $P < .05$. These data indicate that, for studies with one posttest only, no less than 213 unpublished manuscripts reporting nonsignificant findings and, for those with two or more posttests, 17 of such studies had to be in existence in order to constitute a challenge to the contention of this meta-analysis that the effects of surgery are "real," ie, deviate significantly from 0. The Rosenthal criterion, which is based on the number of studies rather than on ESs published, modifies these values to 95 and 35, respectively. As 213 is larger than 95 and 17 is less than 35, one can conclude from this N_{fs} analysis that the treatment effects cited for posttest 1 are well protected from potential bias by nonpublished, nonsignificant research that would contradict them, while those cited for posttest 2 are not. In other words, the reader can have confidence in the unbiased nature of the treatment effects of geriatric surgery cited for the initial postoperative measurement, but not for those observed in its subsequent follow-up (posttest 2).

TABLE 7
Fail-Safe N Analysis for Type 1 Error Publication Bias

	Postsurgical Time	
Analytic Procedures	Posttest 1	Posttest 2
Number of studies	17*	5
Calculated N_{fs} $(\Sigma z \div 1.64)^2 - 10$	213	17
Rosenthal criterion $(5 \times N) + 10$	95	35
Outcome	$213 > 95$	$17 < 35$

*This number includes one study (Miller *et al*[42]) that reported two separate outcomes and thus was counted twice.

Discussion

Reviewing the multiple findings of this meta-analytic review for their scientific relevance, the critical reader may well isolate some three or four outcomes as particularly pertinent.

First, there appears to be compelling evidence to suggest that the research designs used in past studies on the mental status effects of geriatric surgery are generally lacking in methodologic rigor. The modal design employed was, in essence, a preexperimental one-group, posttest only design that allows for few scientifically valid interferences. Only 33.3% of the studies used a comparison group of any kind and, when they did, comparison subjects were generally nonequivalent in age to the treatment group. Moreover, only five of the 18 studies in the review were designed to record more than one postoperative measurement of patient mental status, suggesting greater research interest in the short-term and transient, rather than the long-term and more permanent, treatment effects of geriatric surgery. It also should be noted that neither type of operation nor type of anesthesia were manipulated in any one of the studies as a within-study design factor. These methodologic deficits have led to the accumulation of rather fragmented information about the *specific* treatment effects of particular types of surgery and anesthesia but not to generalized knowledge: as of this writing, we do not really know whether postoperative mental decline is a disease-specific phenomenon or a more generic effect that cuts across a multitude of geriatric diseases requiring surgical intervention. This meta-analytic review carries a strong suggestion that the latter may be the case, but meta-analysis is no substitute for direct empirical verification procedures. Finally, it should be noted that the sample sizes of the studies analyzed were apt to be small (median, 65; range, 9 to 1600), preventing any reliable estimation of population effects.

A second meta-analytic finding worth noting is the differential moderating effect on surgical outcomes of such basic demographic attributes as patient age and sex. Age was found to be a good predictor of postoperative mental status changes of all kinds, with those of more advanced age more likely to suffer from diminution of mental function than those of younger senescent status, not a surprising outcome. As for sex, it may be predictive of the kind of mental impairment most likely to occur with women manifesting a greater affinity for delirious, and men for cognitive, decompensation.

A third finding presenting itself with sufficient clarity in this meta-analysis is the fact that past research has given us a reasonable understanding of the magnitude and direction of the short-range effects of geriatric surgery on patient mental status, but not of its more distant, long-term sequelae. On the latter score, the empirical evidence, currently available, is so sparse that it could not even be protected from potential publication bias. As was noted in the results enumerated, the confidence with which we could describe true posttest 2 treatment effects was below the conventional standards of scientific precision.

Needless to say, all of these findings have important implications for future research within this domain of inquiry. Foremost among them is the requirement that research endeavors yet to come have to be of considerably greater methodologic rigor than those of the past. At a minimum, they should be characterized by the following design attributes: (1) "type of surgery" (operative procedure) should be a systematically manipulated within-study design factor; (2) postoperative measurement of patient mental status should occur over a much longer time frame than the immediate postsurgical recovery period only; and (3) the typical study sample size should be increased to a critical n capable of detecting population effects of clinically and scientifically relevant size.

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