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Visual and hearing impairment in elderly patients hospitalized for rehabilitation following hip fracture

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Abstract—In a prospective study, we assessed the prevalence and significance of visual and hearing impairment in 896 patients who were hospitalized for rehabilitation following hip fracture. Visual impairment was defined as visual acuity equal to worse than 6/60 in the better of the two eyes. Hearing impairment was defined as mean decibel level equal to or higher than 60 in the better of the two ears. Visual impairment was found in 210 patients (23.4%) and hearing impairment was found in 231 patients (25.8%). Simultaneous visual and hearing impairment was seen in 72 patients (8%). In univariate analysis, the absolute efficacy of rehabilitation was significantly lower in patients with visual impairment compared to those without (p = 0.00001) and in patients with hearing impairment compared to those without (p = 0.002). However, in multivariate analysis, visual, but not hearing, impairment was found to be independently associated with the absolute efficacy of rehabilitation (p = 0.001). In light of these results, we propose that in the first phase of rehabilitation, patients' visual acuity needs to be optimized.

Key words: aging, elderly, hearing impairment, hip fracture, rehabilitation, sensory impairment, visual impairment.

INTRODUCTION

Hip fracture (HF) is a common traumatic event in the elderly population, causing significant mortality and morbidity in this age group. Surgical repair followed by rehabilitation is the treatment of choice. The rehabilitation process enables elderly patients to return as closely as possible to their premorbid functional status. The prevalence of visual and hearing impairment increases with age, attaining a high ranking among chronic impairments of the elderly [1–4]. Although visual impairment was found to be a significant risk factor for HF in the elderly [5], its effect, as well as that of hearing impairment on the success of rehabilitation following HF, has not been investigated to date, to our knowledge.

Thus, this prospective study (1) assessed the prevalence of these two sensory impairments in elderly patients undergoing rehabilitation following HF, (2) compared the outcome of rehabilitation in patients with and without each of these impairments, and (3) determined the independent effect of each of these impairments on rehabilitation success.

METHODS

Patients

The study population consisted of all patients 65 years and older hospitalized for rehabilitation following surgical

Abbreviations: FIM = Functional Independence Measure, GDS = Geriatric Depression Scale, HF = hip fracture, MMSE = Mini-Mental Status Examination, SD = standard deviation.

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repair of HF in the 89 months between March 1, 1996, and July 31, 2003, in the geriatric ward of the Soroka Medical Center in Beer-Sheva, Israel. Prior to their transfer to the geriatric department, all the patients were hospitalized in the orthopedic surgery department of the same medical center where they underwent surgery for HF. Following the operation, a senior geriatric consultant examined the patients and assessed whether they were suitable for rehabilitation. Only those patients who were found to be reasonable candidates for rehabilitation were transferred to the geriatric ward, where they underwent a conventional rehabilitation program. In any borderline case, the patient enjoyed the benefit of the doubt and was admitted for rehabilitation. In most cases, patients with advanced dementia and/or those with a low premorbid functional status were not transferred for rehabilitation. The Committee for Research on Human Beings (the Helsinki Committee) of the Soroka Medical Center approved the study, and all patients gave informed consent before enrollment.

Measurements

After giving informed consent to participate in the study, all patients or their families provided demographic, social, and educational information, including smoking histories. Data relating to chronic comorbidity were collected from primary care and previous hospitalization records. Blood samples were tested by conventional methods for levels of folic acid and vitamin B12.

During rehabilitation, a study nurse performed screening for visual impairment using the standard Snellen eye chart with the patients wearing their own eyeglasses, with optimal acuity set at 6/6 (meters) and reduced vision indicated by a higher denominator. Visual impairment was defined as visual acuity equal to or worse than 6/60 in the better of the two eyes [6].

Screening for hearing impairment was done with the use of the GSI-16 audiometer (Grasson-Stadler, Madison, Wisconsin) at 500, 1,000, 2,000, and 4,000 Hz. For this analysis, mean decibel levels over the four frequencies were computed. Hearing impairment was defined as mean decibel level equal to or higher than 60 dB in the better of the two ears [7]. Twenty-one patients (2.3%) had hearing aids, but only eleven used them. In these patients, hearing was assessed with the patients wearing their hearing aids.

We evaluated mental status using the Folstein Mini-Mental Status Examination (MMSE) with a scale ranging from 1 to 30 and a cutoff for normal of 23 and above [8]. In patients with severe visual impairment, the four items in the standard MMSE that could not be conducted with this degree of impairment were deleted. In these patients, the final MMSE score was corrected, with the actual score being multiplied by a factor of 1.15. In addition, we assessed each patient for symptoms of depression using the Geriatric Depression Scale (GDS) with scores ranging from 0 to 30 and a cutoff for normal of 10 or less [9]. Patients with hearing impairment who could not undergo the MMSE or GDS vocally were given the tests by means of a written questionnaire. We performed functional assessments and evaluation of the progress of rehabilitation using the Functional Independence Measure (FIM™) scale that ranges from 18 to 126 and is based on a score of 1 to 7 for each of 18 different items, in accordance with the level of independence for each item. With this scoring system, a patient with totally independent function would have a score of 126 points [10]. Prefracture FIM™ scores were determined by recall in an interview conducted with the patient or the patient's family by a senior geriatrician, close to admission. On the admission of a patient to rehabilitation and at the end of rehabilitation, FIM™ scores were determined at a staff meeting of the geriatric ward in which the medical, rehabilitation, and nursing staffs attended. The decision to discharge a patient at the end of the rehabilitation process was reached when FIM™ scores were stable at two successive determinations, 1 week apart.

Statistical Analysis

We analyzed data using the EPI INFO and SPSS (Statistical Package for the Social Sciences) software. Univariate comparisons were performed using the Student's *t*-test or the χ^2 statistic (or its equivalent Kruskal-Wallis test), as appropriate. Inasmuch as 40 univariate comparisons were conducted, statistical significance was set at $p < 0.00125$ throughout. Multivariate analysis was performed with the use of multiple linear regressions, and statistical significance was set at $p < 0.05$ throughout.

RESULTS

During the course of the study, 926 patients were hospitalized for rehabilitation following surgical HF repair. Of these, the 896 patients who underwent screening for visual and hearing impairment composed the study population. The other 30 patients did not undergo screening because of technical reasons unrelated to the

patients or their condition. No significant differences were found in any parameters measured between the patients who were included in the study and those who were not. Of the patients tested, 683 patients were women (76%) and 213 (24%) were men. The mean age of the patients was 78.4 ± 7.2 (standard deviation [SD]) years and the age range was 65 to 98 years.

Visual impairment was found in 210 patients (23.4%). **Table 1** shows the results of the univariate comparison between patients with and without visual impairment of demographic characteristics, common chronic comorbid conditions, smoking rates, rates of vitamin B12 and folic acid deficiency, results of cognitive tests, and hearing impairment. Significant differences were found between these two groups in mean age and the rate of hearing impairment.

Table 2 shows the results of the univariate comparison between patients with and without visual impairment in mean values of functional state by FIM (prior to the HF, on admission to rehabilitation, and at discharge from rehabilitation), length of inhospital rehabilitation, and the absolute efficacy of rehabilitation. All these parameters were significantly higher in patients without visual impairment.

Two hundred and thirty one patients (25.8%) had impaired hearing. **Table 3** shows the results of the univariate comparison between patients with and without hearing impairment of demographic characteristics, common chronic comorbid conditions, smoking rates, rates of vitamin B12 and folic acid deficiency, results of cognitive tests, and visual impairment. Significant differences were found between these two groups in mean age, the Folstein MMSE, and the rate of visual impairment.

Table 4 shows the results of the univariate comparison between patients with and without hearing impairment in mean values of functional state by FIM (prior to the HF, on admission to rehabilitation, and at discharge from rehabilitation), length of inhospital rehabilitation, and the absolute efficacy of rehabilitation. All these parameters were significantly higher in patients without hearing impairment except for length of hospitalization, for which no difference was found.

Of the 896 patients, 369 patients (41%) had either visual or hearing impairment and 72 (8%) had both. In multivariate analysis, all the parameters appearing in **Table 1** with the addition of visual impairment, pre-event FIM, and length of hospitalization served as independent variables with absolute efficacy of rehabilitation as the dependent variable. Visual impairment was found to have a significant independent effect on the absolute efficacy of

Table 1.
Comparison between patients with and without visual impairment of demographic variables, chronic comorbidity and smoking, B12 and folate deficiency, cognitive scores, and hearing impairment.

Variable	No Visual Impairment (*n* = 686)	Visual Impairment (*n* = 210)	*p*-Value
Age (mean ± SD)	77.7 ± 6.9	80.6 ± 7.4	0.000000
Gender (female: *n* [%])	521 (76)	162 (77)	0.72
Ischemic Heart Disease (*n* [%])	228 (33)	72 (34)	0.65
Congestive Heart Failure (*n* [%])	59 (9)	18 (9)	0.80
Atrial Fibrillation (*n* [%])	70 (10)	29 (14)	0.13
Hypertension (*n* [%])	407 (59)	126 (60)	0.83
Diabetes Mellitus (*n* [%])	161 (23)	47 (22)	0.74
Total Number of Diseases (mean ± SD)	2.5 ± 1.6	2.5 ± 1.5	0.83
Smokers (past) (*n* [%])	96 (14)	31 (15)	0.79
Smokers (present) (*n* [%])	41 (6)	19 (9)	0.12
Decreased Folic Acid (<3.0 µg/L) (*n* [%])	46 (6)	14 (7)	0.71
Decreased Vitamin B12 (<250 ng/L) (*n* [%])	278 (41)	83 (40)	0.74
Mini-Mental Status Examination (mean ± SD)	24.2 ± 5.4	23.2 ± 6.7	0.12
Geriatric Depression Scale (GDS) (mean ± SD)	8.8 ± 6.0	9.2 ± 5.8	0.43
Impaired Hearing (*n* [%])	157 (23)	74 (35)	0.0004

SD = standard deviation *n* = total number of sample

Table 2.
Comparison of functional state between patients with and without visual impairment by Functional Independence Measure (FIM) (prior to hip fracture, on admission to rehabilitation, and at discharge from rehabilitation), length of inhospital rehabilitation, and absolute efficacy of rehabilitation. Impairment values are mean ± standard deviation.

Variable	No Visual Impairment (*n* = 686)	Visual Impairment (*n* = 210)	*p*-Value
Pre-Event FIM	116.0 ± 13.0	110.0 ± 18.0	0.000001
Admission FIM	76.0 ± 15.0	68.0 ± 18.0	0.0000001
Discharge FIM	92.0 ± 18.0	81.0 ± 23.0	0.000001
Length of Inhospital Rehabilitation (days)	23.0 ± 9.5	21.0 ± 7.3	0.02
Absolute Efficacy of Rehabilitation*	34.1 ± 17.5	25.5 ± 19.6	0.00001

*(Change in FIM ÷ [maximum FIM – initial FIM]) × 100

Table 3.
Comparison between patients with and without hearing impairment of demographic variables, chronic comorbidity and smoking, B12 and folate deficiency, cognitive scores, and visual impairment.

Variable	No Hearing Impairment (*n* = 665)	Hearing Impairment (*n* = 231)	*p*-Value
Age (mean ± SD)	77.3 ± 6.8	81.3 ± 7.1	0.000001
Gender (female: *n* [%])	512 (77)	171 (74)	0.33
Ischemic Heart Disease (*n* [%])	224 (34)	76 (33)	0.93
Congestive Heart Failure (*n* [%])	57 (9)	20 (9)	0.85
Atrial Fibrillation (*n* [%])	70 (11)	29 (13)	0.43
Hypertension (*n* [%])	396 (60)	137 (59)	0.90
Diabetes Mellitus (*n* [%])	153 (23)	55 (24)	0.50
Total Number of Diseases (mean ± SD)	2.5 ± 1.5	2.6 ± 1.6	0.83
Smokers (past) (*n* [%])	97 (15)	30 (13)	0.46
Smokers (present) (*n* [%])	48 (7)	12 (5)	0.27
Decreased Folic Acid (<3.0 µg/L) (*n* [%])	44 (7)	16 (7)	0.99
Decreased Vitamin B12 (<250 ng/L) (*n* [%])	266 (40)	95 (41)	0.76
Folstein Mini-Mental Status Examination (mean ± SD)	24.8 ± 5.2	22.1 ± 6.3	0.00001
Geriatric Depression Screening Scale (GDS) (mean ± SD)	8.7 ± 5.9	9.2 ± 5.8	0.31
Impaired Vision (*n* [%])	130 (20)	80 (35)	0.0004

SD = standard deviation *n* = total number of sample

Table 4.
Comparison of functional state between patients with and without hearing impairment by Functional Independence Measure (FIM) (prior to the hip fracture, on admission to rehabilitation, and at discharge from rehabilitation), length of inhospital rehabilitation, and absolute efficacy of rehabilitation. All values are mean ± standard deviation.

Variable	No Hearing Impairment (*n* = 665)	Hearing Impairment (*n* = 231)	*p*-Value
Pre-Event FIM	117.0 ± 13.0	111.0 ± 16.0	0.0000001
Admission FIM	77.0 ± 15.0	69.0 ± 16.0	0.0000001
Discharge FIM	92.0 ± 18.0	84.0 ± 20.0	0.0000001
Length of Inhospital Rehabilitation (days)	22.7 ± 9.0	22.5 ± 8.0	0.60
Absolute Efficacy of Rehabilitation*	34.1 ± 18.2	28.7 ± 17.8	0.0002

*(Change in FIM ÷ [maximum FIM – initial FIM]) × 100

rehabilitation (p = 0.001, β = –0.01, regression coefficient = –4.518) (β = the standardized regression coefficient in multiple regression). In contrast, hearing impairment was not significantly associated with the absolute efficacy of rehabilitation in this analysis (p = 0.34).

DISCUSSION

Rehabilitation following HF in the elderly patient is a complex process, the success of which is contingent upon a range of interacting clinical and functional parameters. An important factor is the common impairment of the visual and/or hearing capacity in these patients. The association between these impairments and the success of rehabilitation was the focus of this study.

Two methodological aspects of our study need to be addressed. The first is that not all patients who suffered HF and had surgical repair were transferred for rehabilitation and included in the study. As mentioned earlier, a senior geriatrics physician evaluated all patients before deciding who had a reasonable chance of rehabilitation, and only those patients latter were transferred to the rehabilitation department. In any borderline case, the patient enjoyed the benefit of the doubt and was admitted for rehabilitation. In most cases, patients with advance dementia and/or those with a low premorbid functional status were not transferred for rehabilitation. A random sample over 1 year showed that the percentage of these types of patients was 9.8 percent of all patients undergoing surgery for HF. This situation led, inevitably, to a selection bias in the study populations. The second methodological issue is the assessment of the outcome of rehabilitation at one point in time, i.e., discharge from the hospital, without follow-up. Follow-up assessments at various time points after discharge could have provided additional, interesting data, although at the ages of the patients in this study, it is difficult to isolate the variable of rehabilitation success among all the factors that affect the patient's functional status.

To conduct statistical analyses, we determined a threshold value for each of the impairments. Although (to a certain degree) this determination was arbitrary, it was set at the line between moderate and severe impairment under the assumption that in the range of severity of these impairments, this is the critical point in terms of functional capacity.

Approximately one-quarter of the study population had visual impairment and a similar rate had hearing impairment. In the absence of other studies in which a similar threshold was used, comparing this rate with other populations was impossible.

In comparing patients with and without visual or hearing impairment (**Tables 1** and **3**), we were not surprised to find a significant difference in mean age. This finding is consistent with the known fact that these impairments increase with age. Another finding in this context is the high rate of hearing impairment among patients with visual impairment (**Table 1**) and of visual impairment in patients with hearing impairment (**Table 3**). These associations are also most likely age-related.

We did not find a significant difference in vitamin B12 or folic acid levels between patients with and without hearing impairment. This finding is not in keeping with the findings of a previous study that reported an association between B12 and folate deficiency and hearing impairment in 55 elderly patients [11].

The principal finding in this study is that the absolute efficacy of rehabilitation is significantly lower among patients with visual and hearing impairment compared to those without, by univariate analyses. In contrast, multivariate analysis showed that visual, but not hearing, impairment was significantly associated with this important outcome variable. The significant difference in rehabilitation success found to be related to hearing impairment on univariate analysis stems primarily from the effect of age and visual impairment, as seen in the multivariate analysis.

This principal finding of the study highlights and emphasizes the existing difference between the visual and hearing senses in terms of the effect on the rehabilitation process in the elderly age group. While impaired vision has a severe impact on elderly individuals' daily level of function and their ability to adjust to changing conditions, impaired hearing has a much lesser effect. The explanation for this difference in influence of these two senses on function and rehabilitation lies in the difference in compensatory possibilities in response to impairment of these senses. While impaired hearing can be compensated for by speaking with a raised voice close to the elderly patient's ear and the aid of other senses, including hand movements, compensation for impaired vision is much more limited.

We tested visual acuity using the eyeglasses that the patient used prior to the HF. These glasses did not always correct the visual acuity to an optimal degree. In

accordance with the study finding that visual impairment reduces the efficacy of rehabilitation, one should conclude that it is imperative to achieve an optimal correction of visual acuity at the initial stages of the rehabilitation process. This correction, which can improve the chances of a successful rehabilitation, could even be cost-effective. Practically speaking, we suggest that an optometrist test visual acuity in elderly patients toward the beginning of rehabilitation and that eyeglasses be prescribed to improve visual acuity to the optimal extent. Another common correctable condition that causes visual impairment in some elderly patients is the cataract. Surgical repair of this problem before rehabilitation begins is not as easy as fitting glasses, but with today's advanced technologies, one should not reject this option outright, but should weigh it seriously.

CONCLUSIONS

Approximately 25 percent of patients undergoing rehabilitation following HF have a serious visual impairment and a similar percentage have hearing impairment. Patients with these impairments are older, have a lower pre-event functional status, and often have both impairments simultaneously. Visual, but not hearing, impairment has a significant, independent negative effect on the absolute efficacy of rehabilitation. In light of the findings of this study, we propose that in the first phase of rehabilitation, patients' visual acuity needs to be optimized.

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