Original Article

Role of handgrip strength testing in pre-anaesthetic check-up: A prospective cross-sectional study

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Abstract

Background and Aims: Frailty has been known to be associated with postoperative adverse events and longer hospital length of stay (LOS). Hand grip strength (HGS) is one of the parameters of measuring frailty. The aim of the study was to correlate preoperative handgrip strength and 30-day outcome of patients undergoing major abdominal surgery. It also aimed to evaluate the role of the standard preoperative variables like metabolic equivalents, revised cardiac risk index (RCRI), serum albumin, and serum creatinine along with their association with HGS testing in determining the postoperative outcome in surgical patients.

Material and Methods: This prospective observational study included 149 American Society of Anesthesiologists class III/IV patients presenting for major abdominal surgery. A mean of three measurements of dominant HGS using Camry hand dynamometer was measured. The patients were divided into groups: weak, normal, and strong depending on grip strength. Patients were followed for 30 days and postoperative outcome in terms of ventilatory support, admission to intensive care unit, cardiac complications, in-hospital mortality, and LOS were recorded. Observational data obtained were reported as mean value and analyzed using Student's *t*-test or Wilcoxon/Mann–Whitney Rank test. Associations between RCRI, serum albumin, and LOS with HGS were evaluated using logistic regression.

Results: The hospital LOS was significantly longer in patients with weak HGS (15.11 ± 11.03 days versus 10 ± 5.71 days, $P = 0.001$). Patients with weak HGS had significantly lower mean serum albumin levels compared to normal HGS ($P = 0.0001$) and a statistically significant RCRI score ($P = 0.013$).

Conclusion: HGS can be used as a preoperative test in predicting hospital LOS after major surgery.

Keywords: Frailty, hand grip strength, length of hospital stay

Introduction

Postoperative complications and mortality have been seen in a considerable subset of surgical patients.[1] Several factors such as old age, body mass index (BMI), high visceral fat area, higher American Society of Anesthesiologists (ASA) physical status, and multiple comorbidities have previously been identified as risk factors for surgeries. It is important to preoperatively evaluate and define the patients with high risk for postoperative morbidity and mortality. Preoperatively measurements of exercise capacity, muscle strength, and a detailed evaluation of cardiac status of

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the patient by using cardiopulmonary exercise testing may be challenging for immobile patients.[2]

Sarcopenia, characterized by a progressive and generalized decrease in amount and strength of skeletal muscle, has been associated with a poor postoperative outcome and increased hospital length of stay (LOS). Hand grip strength (HGS) is a simple, cheap, nontime consuming test, which has been used as an effective evaluation tool to measure frailty. Previous data on HGS showed that it is a predictor of disease, disease-specific mortality, and longevity.[3,4] Diminished HGS is associated with poor perioperative outcomes and high mortality as seen in patients with metabolic diseases.[5] The literature is inconsistent; however, a few studies have shown that a weaker HGS is associated with readmission and a longer hospital LOS.[6] In the perioperative scenario although it may not be possible to modify frailty, but counseling regarding prediction of outcome and treatment options can be planned. The primary objective of our study was to correlate preoperative HGS and 30-day outcome of patients undergoing major surgery. We also aimed to evaluate the role of the standard preoperative variables like metabolic equivalents, revised cardiac risk index (RCRI), serum albumin, and serum creatinine along with their association with HGS testing in determining the postoperative outcome in surgical patients.

Material and Methods

After approval from the institutional ethics committee, IEC No: 2018-286 we conducted a prospective observational study during a period of 1 year from June 2018 to May 2019 in a tertiary care hospital. We included adult ASA class III and IV patients posted for major elective/emergency abdominal surgery.[7] To guarantee the privacy of study subjects, we followed the declaration of Helsinki. Patients who were unable to comprehend the commands or use the dynamometer freely and were hemodynamically unstable were excluded from the study.

A thorough preanesthetic check-up comprising of detailed history and physical examination was conducted. HGS was measured using Camry hand dynamometer at time of preanesthetic checkup by a trained research assistant and expressed in kilograms (Kg). The patient was made to sit holding the dynamometer in the dominant hand with arm extended parallel to the ground. Adjustment of the dynamometer was done in such a way that patient's palm rested on its base and middle of the four fingers could comfortably hold the handle. Then by using maximal isometric effort, patient was instructed to compress the dynamometer without any other movement and to maintain the sustained grip for 5 s. This was performed thrice with recovery period of 15 s between each effort and a mean of the three values was taken. The mean value was compared with the age and sex standardized chart [Appendix 1] and HGS was classified as grade 1 (weak), grade 2 (normal), and grade 3 (strong).

Investigations in the form of complete blood count, renal function tests, liver function tests including serum albumin, chest X-ray, and electrocardiography were obtained prior to surgery. The RCRI, which is used routinely in our institution to assess cardiac risk, was also calculated. On arrival in the operation theatre, standard ASA monitoring was started and baseline vital parameters were recorded. All patients were anesthetized using a standard protocol by the consultant anesthesiologist. Patients were followed for 30 days and postoperative outcome in terms of ICU admission, need for inotropic or ventilatory support, cardiac complications, hospital LOS, and mortality was recorded.

Statistical analysis

Data were described in terms of range; mean ± standard deviation (±SD), median, frequencies (number of cases), and relative frequencies (percentages) as appropriate. Comparison of quantitative variables between the study groups was done using Student's *t*- test and Mann–Whitney U test for independent samples for parametric and nonparametric data, respectively. For comparing categorical data, Chi-square test was performed and exact test was used when the expected frequency is less than 5. Associations between RCRI, serum albumin, and hospital LOS with HGS were evaluated using logistic regression. A probability value (*P* value) less than 0.05 was considered statistically significant. All statistical calculations were done using Statistical Package for the Social Sciences 21 (SPSS Inc., Chicago, IL, USA) version statistical program for Microsoft Windows. A post hoc power analysis was conducted using the software package, G*Power version 3.1.9.2 (Franz Faul, University of Kiel, Kiel, Germany). The alpha level used for this analysis was $P < 0.05$ and beta was 0.20. Sample size was calculated using the hospital stay as the parameter, which is the primary outcome of our study. Our power of the study come out 0.94 and with an effect size of 0.58 with $\alpha = 0.05$, $\beta = 0.20$, and confidence interval of 95%.

Results

We identified a total of 170 eligible patients, of which 21 refused to participate in the study, two requested removal from the study, and one was excluded as the case was canceled. The demographic data of the patients with weak and normal/strong HGS were similar, with no significant differences in gender, age, BMI, METs, and serum creatinine [Table 1]. All 149 participants underwent both HGS measurement and RCRI

calculation. The average number of RCRI components for weak HGS patients was significantly higher ($P = 0.013$) than that for normal HGS patients (mean ± SD, 1.76 ± 0.78 for weak; 1.45 ± 0.59 for normal). The overall mean for serum albumin was 3.44 ± 0.73 $g{\cdot}dL^{-1}$ for patients with weak HGS as compared to 3.9 ± 0.73 $g{\cdot}dL^{-1}$ for normal HGS ($P = 0.0001$) as in Table 2. The indicators of postoperative complications like need for inotropic/ventilatory support/ICU admission, in hospital morbidity/mortality, were comparable in patients with different HGS. There was no mortality in our study population. The hospital LOS was significantly longer in patients with weak HGS (15.11 ± 11.03 days versus 10 ± 5.71 days, $P = 0.001$) as shown in Table 3. Serum albumin was significantly associated with frailty in a simple logistic regression model (odds ratio, 0.557; 95% confidence interval, 0.325–0.954; $P = 0.033$), which means that patients with weaker grip strength had lesser serum albumin. There was a significant association with hospital LOS (odds ratio, 1.058; 95% confidence interval, 1.003–1.116; $P = 0.039$), that is patients who had lesser grip strength had a longer hospital stay [Table 4].

Discussion

In this prospective study, a weaker HGS was significantly associated with lower levels of serum albumin, higher RCRI score, and a longer hospital LOS in patients undergoing major abdominal surgery. The study subjects in weak and normal/strong groups of HGS were comparable with regard to age, gender, BMI, metabolic equivalents, and serum creatinine.

HGS is the measurement of the maximum isometric strength of the hand and forearm muscles. Grip strength is measured using a handheld dynamometer and can be performed at the bedside to evaluate frailty.[8] It is a useful tool to predict the overall health as well as risk of cardiovascular disease. Different types of equipment and methods have been used for evaluating HGS. We used Camry's digital hand dynamometer, in which the measurements for HGS were standardized for different age groups and gender. The cutoff value for weak HGS has been shown to be <26 kg for men as compared to <18 kg for women in a study by Asian working group of sarcopenia.[9] Although this handgrip dynamometer has been used in Western population, not much data are available for Indian population. A previous study done by Mahalakshmi *et al.* established normal values for Indians and values of <85% of normal were taken as abnormal. They found that in controls, HGS was 5–15 kg lower than those in the Western population for each age–sex standardized group.[10] This difference could be because of variation in built and general physical health status of Indian population. In contrast to the previous studies, our study did not report any difference in muscle strength on the basis of gender. This could be due to use of different dynamometer in our study population. An independent association of sarcopenia with physical disability, functional impairment, and mortality has been shown. Mortality in young, middle-aged, and older individuals has been shown to have a significant relationship with HGS.[11,12] A few studies have investigated the relationship between HGS and hospitalization.[13,14] A study in older individuals by Cawthon *et al.* showed a 56%

Table 1: Demographic profile of patients

	Weak (*n*=85)	Normal (*n*=64)	*t*/Chi-square value	*P*
Age (mean±SD)	54.28±16.25	56.47±13.59	−0.871	0.385
Gender				
Male	39 (45.9%)	33 (51.6%)	0.472	0.492
Female	46 (54.1%)	31 (48.4%)		
BMI (Mean±SD)	25.56±6.01	26.68±6.11	−1.103	0.272
METs				
>4	58 (68.2%)	50 (78.1%)	1.79	0.181
<4	27 (31.8%)	14 (21.9%)		
Serum creatinine	0.88±0.62	0.89±0.48	−0.132	0.895

Table 2: Frailty-related outcomes

	Weak (*n*=85)	Normal (*n*=64)	*t*/Chi-square value	*P*
RCRI				
1	37 (43.5%)	38 (59.4%)	9.116	0.167
2	32 (37.6%)	23 (35.9%)		
3	15 (17.6%)	3 (4.7%)		
4	1 (1.2%)	0 (0%)		
Sum of RCRI components	1.76±0.78	1.45±0.59	2.511	0.013
Serum albumin	3.44±0.73	3.90±0.73	−3.790	0.0001

Table 3: Postoperative outcomes

Postoperative Parameter	Weak (*n*=85)	Normal (*n*=64)	Chi-square value/*Z*	*P*
Start of inotropes	6 (7.1%)	2 (3.1%)	1.907	0.385
ICU admission	3 (3.5%)	1 (1.6%)	0.541	0.462
Ventilator support	2 (2.4%)	1 (1.6%)	1.444	0.486
Cardiac event tachycardia	1 (1.2%)	0 (0%)	0.758	0.384
Length of stay	15.11±11.03	10±5.71	3.377	0.001

Table 4: Logistic regression models for frailty status

	P	Odd ratio	95% CI for odd ratio	
			Lower	Upper
Serum albumin	0.033	0.557	0.325	0.954
RCRI	0.227	1.368	0.823	2.274
Length of stay	0.039	1.058	1.003	1.116

increased risk of hospitalization in patients with lower HGS when followed for 4.7 years.[13]

Very few studies have investigated the association of weak HGS with hospital LOS, morbidity, and mortality in the surgical patient. In our study, patients with weaker HGS had a statistically significant longer hospital LOS, which was similar with the results of Mahalakshmi *et al.*[10] Revenig *et al.* prospectively evaluated frailty using five components of the Fried criteria among patients undergoing major abdominal procedures and found that when used with ASA score and hemoglobin levels, frailty assessment can provide strong information.[3] Risk of perioperative complications and mortality has been shown to have an alliance with frailty in patients undergoing colorectal and cardiac surgeries.[4] Reduced strength has been strongly correlated with the presence of postsurgery complications, longer LOS, reduced functional capacity, and decreased survival rate in other studies.[15] In a study by Joseph *et al.*, major complication (sepsis, pneumonia, and deep venous thrombosis) rates in patients undergoing emergency general surgery were three times higher in frail patients than in robust.[16] There was no significant difference among need of ionotropic support, cardiovascular events, ventilatory support, and ICU stay in our study, which may be due to the small study sample. In patients with femoral neck fracture and carcinoma of esophagus, HGS was found to be a good indicator to predict the occurrence of both mortality and morbidity.[17,18] Similarly, in our study, although the results were equivocal amongst the groups, but we found a fall in blood pressure and ICU admission in two of our patients with weak HGS. Whether the results can be applicable to all types of surgical patient groups is not known. However, preoperative knowledge of frailty status can help the treating doctors to plan a robust perioperative strategy to minimize the risk in such patients. Once a patient is identified as frail and is scheduled for surgery, preoperative optimization of comorbidities and better postoperative monitoring can be implemented.

We evaluated the patients for other parameters like RCRI and serum albumin also. RCRI score was used to weigh the patient's risk of perioperative cardiac complications. In our study patients, the weaker HGS group had a higher average RCRI score and the value was statistically significant, which was similar to patients undergoing vascular surgery in a study done by Reeve *et al.*[4] Cho *et al.* observed that in patients undergoing lower extremity bypass surgery, the hospital LOS increased 3.23 days for each unit increase in RCRI.[19] Another variable that was found to be significantly associated with HGS in our study was serum albumin. To assess the nutritional status and disease severity in elderly, serum albumin is most often used as a marker. Age-related loss of muscle mass and muscle function can also be assessed. A statistically significant association between change in muscle mass and muscle strength with serum albumin has been found in previous studies.[20,21] We found a positive correlation between lower serum albumin levels and weak HGS. Our results were similar to Revening *et al.* who also found a positive correlation between lower albumin and frailty in patients undergoing abdominal surgery.[3] Mahalakshmi *et al.* found a significantly higher risk of major postoperative complications and longer hospital LOS (*P* value 0.0003 and 0.004, respectively) in patients with low serum albumin (<2.5 g·dL^{-1}).[10]

There are a number of unique aspects to our study. The frailty assessment was assessed in patients undergoing major abdominal surgeries and they are therefore at a higher risk of morbidity. Our study group included all adults and did not focus only on elderly patients.

Our study has certain limitations. Our research was a single-center study with fewer patient population, however despite this we observed a relationship between a weaker HGS and hospital LOS. Some parameters like site of incision, nature of surgery (emergency versus elective), and development of postoperative complications could have affected postoperative outcome and LOS.

To conclude, HGS testing is a feasible, pragmatic, real-time bedside tool that may enhance preoperative risk stratification. It can be used as a complimentary test to clinical scoring in identifying patients at risk of complications after surgery. Further rigorous studies are suggested to validate the

association of poorer postoperative outcomes and mortality with impaired preoperative handgrip strength.

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Conflicts of interest
There are no conflicts of interest.

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Appendix 1: Muscle strength testing with Camry's handgrip dynamometer according to age and gender

Age	Male			Female		
	Weak	Normal	Strong	Weak	Normal	Strong
18-19	<35.7	35.7-55.5	>55.5	<19.2	19.2-31.0	>31.0
20-24	<36.8	36.8-56.6	>56.6	<21.5	21.5-35.3	>35.3
25-29	<37.7	37.7-57.5	>57.5	<25.6	25.6-41.4	>41.4
30-34	<36.0	36.0-55.8	>55.8	<21.5	21.5-35.3	>35.3
35-39	<35.8	35.8-55.6	>55.6	<20.3	20.3-34.1	>34.1
40-44	<35.5	35.5-55.3	>55.3	<18.9	18.9-32.7	>32.7
45-49	<34.7	34.7-54.5	>54.5	<18.6	18.6-32.4	>32.4
50-54	<32.9	32.9-50.7	>50.7	<18.1	18.1-31.9	>31.9
55-59	<30.7	30.7-48.5	>48.5	<17.7	17.7-31.5	>31.5
60-64	<30.2	30.2-48.0	>48.0	<17.2	17.2-31.0	>31.0
65-69	<28.2	28.2-44.0	>44.0	<15.4	15.4-27.2	>27.2
70-79	<21.3	21.3-35.1	>35.1	<14.7	14.7-24.5	>24.5