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Patients with limited health literacy have worse preoperative function and pain control and experience prolonged hospitalizations following shoulder arthroplasty

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Background: Patients with limited health literacy (LHL) may have difficulty understanding and acting on medical information, placing them at risk for potential misuse of health services and adverse outcomes. The purposes of our study were to determine (1) the prevalence of LHL in patients undergoing inpatient shoulder arthroplasty, (2) the association of LHL with the degree of preoperative symptom intensity and magnitude of limitations, (3) and the effects of LHL on perioperative outcomes including postoperative length of stay (LOS), total inpatient costs, and inpatient opioid consumption.

Methods: We retrospectively identified 230 patients who underwent elective inpatient reverse or anatomic shoulder arthroplasty between January 2018 and May 2021 from a prospectively maintained single-surgeon registry. The health literacy of each patient was assessed preoperatively using the validated 4-item Brief Health Literacy Screening Tool. Patients with a Brief Health Literacy Screening Tool score ≤ 17 were categorized as having LHL. The outcomes of interest were preoperative patient-reported outcome scores and range of motion, LOS, total postoperative inpatient opioid consumption, and total inpatient costs as calculated using time-driven activity-based costing methodology. Univariate analysis was performed to determine associations between LHL and patient characteristics, as well as the outcomes of interest. Multivariable linear regression modeling was used to determine the association between LHL and LOS while controlling for potentially confounding variables.

Results: Overall, 58 patients (25.2%) were classified as having LHL. Prior to surgery, these patients had significantly higher rates of opioid use ($P = .002$), more self-reported allergies ($P = .007$), and worse American Shoulder and Elbow Surgeons scores ($P = .001$), visual analog scale pain scores ($P = .020$), forward elevation ($P < .001$), and external rotation ($P = .022$) but did not significantly differ in terms of any additional demographic or clinical characteristics ($P > .05$). Patients with LHL had a significantly longer LOS (1.84 ± 0.92 days vs. 1.57 ± 0.58 days, $P = .012$) but did not differ in terms of total hospitalization costs ($P = .65$) or total inpatient opioid consumption ($P = .721$). On multivariable analysis, LHL was independently predictive of a significantly longer LOS (β, 0.14; 95% confidence interval, 0.02-0.42; $P = .035$).

This study was approved by the institutional review board of New England Baptist Hospital (project no. 1827102).

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Conclusion: LHL is commonplace among patients undergoing elective shoulder arthroplasty and is associated with greater preoperative symptom severity and activity intolerance. Its association with longer hospitalizations suggests that health literacy is an important factor to consider for postoperative disposition planning.

Level of evidence: Level III; Retrospective Cohort Comparison; Prognosis Study

Keywords: Shoulder arthroplasty; health literacy; length of stay; cost; inpatient; clinical outcomes

Health literacy (HL) is defined as an individual's capacity to receive, process, and comprehend health care information.[2,6,32,33,36] Limited health literacy (LHL) has been referred to as a ''silent epidemic,'' as it is estimated that nearly half of all Americans lack the skill set necessary to make informed decisions regarding their health.[36] Concerns regarding the harms of LHL have been substantiated in the medical literature, as it has been associated with worse health-related outcomes, additional health care costs, increased hospitalizations and emergency department visits, and decreased knowledge of disease prevention and management.[6,32,33] These issues are magnified by physicians' tendencies to overestimate their patients' level of HL, as well as the hesitancy of patients with LHL to ask clarifying questions.[11,25-27] To facilitate efficient identification of patients with LHL, a concise 4-question instrument, the Brief Health Literacy Screening Tool (BHLST), has been developed and validated.[7,36,40]

Despite the growing recognition of HL as a social determinant of health and risk factor for disproportionate resource utilization, it remains largely unexplored among shoulder arthroplasty patients.[9,29,34] Multiple cross-sectional studies of hand, foot and ankle, and orthopedic trauma patients have demonstrated that those with inadequate HL have limited comprehension of their musculoskeletal pathology and postoperative instructions.[9,25,31,34,35] Additionally, LHL has been associated with increased postoperative hospital lengths of stay (LOSs), higher incidences of discharges to rehabilitation facilities, and worse postoperative function and satisfaction after lower-extremity arthroplasty.[6,29] Although significant progress has been made in identifying nonmodifiable risks for adverse perioperative outcomes, including extended LOS, non-homebound discharge, increased inpatient opioid consumption, and hospitalization costs associated with shoulder arthroplasty, the utility of these findings may be limited to risk-stratification and predictive-modeling purposes.[4,10,12,15,17,19-21] In contrast, HL is a trait that may be influenced by improvements in patient communication and education.[2,6]

The burgeoning demand and costs associated with shoulder arthroplasty require concerted efforts to optimize resource allocation in the postoperative setting.[23,39] HL represents a domain that may provide an opportunity to achieve this goal while simultaneously addressing a barrier to equitable care.[36] The purposes of our study were to determine (1) the prevalence of LHL in patients undergoing shoulder arthroplasty, (2) the association of LHL with the degree of preoperative symptom intensity and magnitude of limitations, (3) and the effects of LHL on perioperative outcomes including postoperative LOS, total inpatient costs, and inpatient opioid consumption.

Methods

This was a retrospective study performed at an urban orthopedic specialty hospital in the United States. We queried consecutive patients who underwent elective inpatient primary reverse or anatomic shoulder arthroplasty between January 2018 and May 2021 from a prospectively maintained electronic registry (OBERD, Columbia, MO, USA). All procedures were performed by a single fellowship-trained shoulder surgeon. The HL of each patient was assessed preoperatively using the validated BHLST, a concise 2-minute survey designed to assess the patient's HL on a 20-point scale.[7,40] The BHLST consists of the following 4 questions: (1) ''How confident are you filling out medical forms by yourself?'' (2) ''How often do you have someone help you read hospital materials?'' (3) ''How often do you have problems learning about your medical conditions because of difficulty understanding written information?'' (4) ''How often do you have a problem understanding what is told to you about your medical condition?'' All questions' response options are presented on a 5-point Likert scale. Patients with BHLST scores $\leq$ 17 were categorized as having LHL, and those with scores $>$ 17 were categorized as having high health literacy (HHL). This threshold value has been previously demonstrated to have high levels of sensitivity and specificity for detecting patients with inadequate to marginal levels of HL.[7] Patients with scores below this threshold represented the bottom quartile of BHLST scores in our study. Patients were eligible for participation in the study if they were aged $\geq$ 18 years, spoke English, completed the BHLST preoperatively, and underwent primary inpatient reverse or anatomic shoulder arthroplasty. Patients were excluded if they underwent revision arthroplasty or had a traumatic indication for surgery. Postoperative pain control regimens were uniform across all patients. Preoperatively, all patients received celecoxib, pregabalin, acetaminophen, and a single-injection ultrasound-guided interscalene or supraclavicular nerve block. Postoperatively, patients were provided acetaminophen and ketorolac, unless contraindicated, and narcotic pain medications on an as-needed basis.

Electronic medical records and the prospectively maintained registry were reviewed to obtain demographic data and relevant patient characteristics for assessment. These included age; sex;

address; race; limited social support (defined as a single, divorced, or widowed marital status); number of self-reported allergies; body mass index (BMI); current smoking status; American Society of Anesthesiologists (ASA) score; presence of comorbid conditions including diabetes, depression, hyperlipidemia, and hypertension; preoperative opioid use (defined as daily opioid use prior to surgery); procedure type (anatomic or reverse total shoulder arthroplasty); insurance type (Medicare, Medicaid, workers' compensation, or private); inpatient opioid consumption (converted to oral morphine equivalents); peak inpatient visual analog scale (VAS) pain score (defined as the highest VAS pain score recorded in the nursing records); discharge disposition (rehabilitation or home); and postoperative hospital LOS. Neighborhood-level socioeconomic deprivation was measured using the Area Deprivation Index (ADI).[13,14] The ADI integrates 17 variables pertaining to the domains of income, education, employment, and housing quality to quantify an individual's level of socioeconomic deprivation, categorized by state-level census blocks.[13,14] Higher ADI ratings signify increasing levels of socioeconomic deprivation. Each patient's home address was used to query his or her corresponding census block and ADI. Patients' national-percentile and state-decile ADIs were recorded. State-decile ADIs were categorized into 3 groups: least disadvantaged group (ADI deciles 1-3), middle group (ADI deciles 4-6), and most disadvantaged group (ADI deciles 7-10).[3]

Among the outcomes of our study were the degree of preoperative symptom intensity and magnitude of limitations, as measured by preoperative range of motion and patient-reported outcome measures (PROMs). During the preoperative visit, preoperative active range of motion was measured using a goniometer to calculate forward elevation and external rotation. Internal rotation was determined by the uppermost vertebral level of the spine reached by the thumb of the examined arm. Preoperative PROMs, including the American Shoulder and Elbow Surgeons score, Single Assessment Numeric Evaluation score, and VAS pain score, were prospectively recorded.

The perioperative outcomes of interest in our study included postoperative hospital LOS in days, total cost of hospitalization, and postoperative inpatient opioid consumption. To further analyze LOS, the proportion of patients in each group who were hospitalized $>$ 1 night was assessed. Under the Centers for Medicare & Medicaid Services 3-day payment-window policy, patients must be hospitalized for a minimum of 3 consecutive days postoperatively to extend coverage to extended-care rehabilitation facilities.[16] To minimize this potential source of bias in our LOS analysis, patients with Medicare insurance with a planned discharge to a rehabilitation facility were removed from the LOS analysis. The total costs of hospitalization were estimated for each patient using time-driven activity-based costing (TDABC).[1] This methodology provides more accurate and granular cost estimates than traditional hospital cost accounting.[1,23] Costs are calculated by multiplying the amount of time each resource is used and the cost-per-unit time of that resource. The sum of all resources utilized over the hospitalization is the final cost. Avant-garde Health software (Boston, MA, USA) was used for TDABC calculations. To protect the confidentiality of internal hospital cost data, all costs are presented as standardized values. To further analyze variations in cost, the proportions of patients in the top quartile of costs in the LHL and HHL groups were assessed.

Univariate analysis was performed to assess for associations between level of HL and patient characteristics, baseline PROMs and range of motion, and our defined outcomes. Pearson χ^2 tests, Fisher exact tests, and independent-samples t tests were used when indicated. Continuous variables are presented as means with standard deviations or medians with interquartile ranges, and categorical variables are reported as frequencies and percentages, as indicated. A multivariable linear regression model was used to assess for an independent association between level of HL and postoperative hospital LOS while controlling for variables that, in our determination, may be confounding through clinical expertise. A threshold of $P < .05$ was used for determining statistical significance.

Results

In total, 230 patients were identified for study analysis, 58 (25.2%) of whom were classified as having LHL and 172 (74.8%) of whom were classified as having HHL. A significantly higher proportion of patients with LHL were prescribed opioids preoperatively (25.9% vs. 9.9%, $P = .002$). Patients with LHL had significantly higher numbers of self-reported allergies (3 $\pm$ 3 vs. 2 $\pm$ 2, $P = .007$) and VAS pain scores (6.4 $\pm$ 2.5 vs. 5.6 $\pm$ 2.4, $P = .020$) and had significantly lower preoperative American Shoulder and Elbow Surgeons scores (29.9 $\pm$ 18.3 vs. 38.8 $\pm$ 18, $P = .001$), forward elevation (75° $\pm$ 30° vs. 94° $\pm$ 33°, $P < .001$), and external rotation (23° $\pm$ 16° vs. 29° $\pm$ 17°, $P = .022$) (Table I). There was a trend toward higher ASA scores among patients with LHL (ASA score $>$ 2, 39.7% vs. 28.1%; $P = .099$). There was also a trend toward higher levels of socioeconomic deprivation among patients with LHL (most disadvantaged ADIs, 26.8% vs. 17.5% [$P = .134$]; national-percentile ADIs, 22.3 $\pm$ 18.2 vs. 18.1 $\pm$ 13.3 [$P = .0066$]). There were no significant differences between the groups in terms of age, sex, limited social support, race, BMI, smoking status, presence of comorbid health conditions including depression, insurance type, previous ipsilateral shoulder surgery, diagnosis, preoperative Single Assessment Numeric Evaluation score, preoperative internal rotation, and procedure type (Table I). Patient characteristics are further described in Table I.

Patients with LHL had a significantly longer LOS than those with HHL (1.84 $\pm$ 0.92 days vs. 1.57 $\pm$ 0.58 days, $P = .012$), and there was a trend toward a higher percentage of patients with LHL who spent $>$ 1 night hospitalized (38.9% vs. 27.1%, $P = .098$). We found similar levels of inpatient costs (top quartile, 31% vs. 23.3% [$P = .238$]; standardized costs, –0.03 $\pm$ 1.5 vs. –0.17 $\pm$ 1.2 [$P = .650$]) (Fig. 1), rates of discharge to rehabilitation facilities (6.9% vs. 5.8%, $P = .755$), inpatient consumption of oral morphine equivalents (95.2 $\pm$ 81.9 vs. 101.6 $\pm$ 125.7, $P = .721$), and peak postoperative inpatient pain scores (6.5 $\pm$ 2.2 vs. 6.5 $\pm$ 2, $P = .950$) between patients with LHL and those with HHL.

Multivariable linear regression analysis identified increasing age (β, 0.18; 95% confidence interval [CI], 0.002-0.03; $P = .022$), female sex (β, 0.22; 95% CI, 0.13-0.48;

Table I Univariate analysis of TSA patient characteristics associated with health literacy

Parameter	High health literacy (n = 172)	Limited health literacy[†] (n = 58)	*P* value
Age at surgery, yr, mean (SD)	67.9 (7.7)	69 (9.6)	.36
Female sex, n (%)	86 (50)	30 (51.7)	.82
Non-white race, n (%)	3 (1.7)	2 (3.4)	.6
Limited social support, n (%)[‡]	48 (27.9)	16 (27.6)	.96
BMI, mean (SD)	30.8 (6.4)	31.6 (6.9)	.42
Smoker, n (%)	6 (3.5)	3 (5.2)	.7
No. of allergies, mean (SD)	1.8 (2.1)	2.8 (3.2)	.007*
ASA score > 2, n (%)	48 (28.1)	23 (39.7)	.09
Diabetes, n (%)	18 (10.5)	9 (15.5)	.3
Hypertension, n (%)	99 (57.6)	35 (60.3)	.71
Hyperlipidemia, n (%)	73 (42.4)	29 (50)	.32
Depression, n (%)	42 (24.4)	16 (27.6)	.63
Preoperative opioid use, n (%)	17 (9.9)	15 (25.9)	.002*
Prior ipsilateral shoulder surgery, n (%)	48 (27.9)	18 (31)	.65
Medicare insurance, n (%)	87 (50.6)	32 (55.2)	.55
Private insurance, n (%)	78 (45.3)	24 (41.4)	.6
ADI, n (%)			
State decile			
1-3	85 (49.7)	25 (44.6)	.32
4-6	56 (32.7)	16 (28.6)	
7-10	30 (17.5)	15 (26.8)	
National percentile, mean (SD)	18.1 (13.3)	22.3 (18.2)	.07
Diagnosis, n (%)			
Osteoarthritis	122 (70.9)	44 (75.9)	.64
Rotator cuff arthropathy	39 (22.7)	12 (20.7)	
Other	11 (6.4)	2 (3.4)	
RSA, n (%)	131 (76.2)	47 (81)	.44
Preoperative ASES score, mean (SD)	38.8 (18)	29.9 (18.3)	.001*
Preoperative SANE score, mean (SD)	28.7 (23.1)	24.7 (20.5)	.24
Preoperative VAS pain score, mean (SD)	5.6 (2.4)	6.4 (2.5)	.02*
Preoperative FE, mean (SD)	93.8 (32.5)	75.3 (30.4)	<.001*
Preoperative ER, mean (SD)	28.9 (17.2)	22.9 (15.9)	.02*
Preoperative IR level, n (%)			
Hip	54 (31.8)	25 (43.1)	.06
Sacrum	32 (18.8)	16 (27.6)	
L4-L5	60 (35.3)	15 (25.9)	
L1-L3	20 (11.8)	1 (1.7)	
>L1	4 (2.4)	1 (1.7)	

TSA, total shoulder arthroplasty; *BMI*, body mass index; *ASA*, American Society of Anesthesiologists; *ADI*, Area Deprivation Index; *RSA*, reverse total shoulder arthroplasty; *ASES*, American Shoulder and Elbow Surgeons; *SANE*, Single Assessment Numeric Evaluation; *VAS*, visual analog scale; *FE*, forward elevation; *ER*, external rotation; *IR*, internal rotation.

* Statistically significant at $P < .05$.

† Defined as score ≤ 17 on Brief Health Literacy Screening Tool.

‡ Defined as single, divorced, or widowed marital status.

$P = .001$), depression (β, 0.15; 95% CI, 0.04-0.45; $P = .022$), and LHL (β, 0.14; 95% CI, 0.02-0.42; $P = .035$) as being independently predictive of longer LOSs (Table II).

Discussion

We found that about 1 in 4 patients undergoing elective shoulder arthroplasty had LHL. These patients had significantly higher rates of chronic preoperative opioid use, more self-reported allergies, and worse preoperative pain and function. These patients also demonstrated trends toward worse overall health and higher levels of socioeconomic deprivation. Additionally, patients with LHL had significantly increased LOSs regardless of their age, sex, BMI, overall health, level of socioeconomic deprivation, insurance type, and history of depression. However, the average LOS for these patients was only 6.5 hours longer

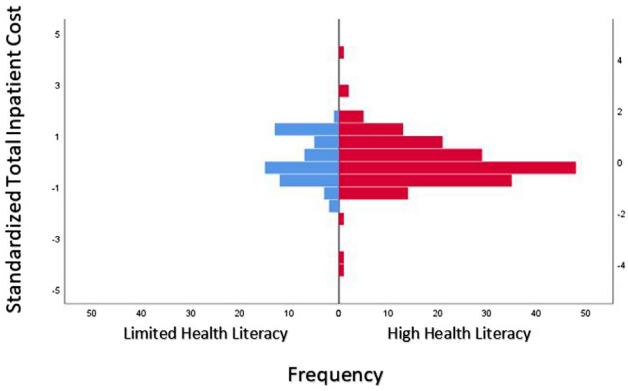

Figure 1 Comparative histogram of total inpatient costs calculated using time-driven activity-based costing methodology following inpatient elective shoulder arthroplasty among patients with high health literacy vs. limited health literacy.

than that for patients with HHL, which is unlikely to be clinically relevant. HL did not influence total inpatient costs or inpatient opioid consumption. Given our findings, providers are encouraged to screen patients for LHL to identify those who may benefit from additional counseling to ensure understanding of their pathology and treatment, as well as to set appropriate expectations for their initial postoperative course. Such strategies may include setting realistic expectations about postoperative pain and functional limitations so that appropriate postoperative pain regimens and social support arrangements can be initiated prior to surgery.[6,8,38]

Given the strong correlation previously described between LOS and episode-of-care costs, shortening the time to discharge has become a focus for optimizing the value of shoulder arthroplasty.[23,28] A salient finding in our study is the significant inverse relationship between HL and LOS following shoulder arthroplasty. However, the average LOS for patients with LHL was only 6.5 hours longer than that for patients with HHL. Additionally, our analysis demonstrated a higher percentage of patients with LHL who stayed $>$ 1 night in the hospital, although this finding did not quite reach the level of statistical significance. Nonetheless, these results may be clinically relevant and they suggest that HL is a factor that warrants consideration when determining candidacy for outpatient shoulder arthroplasty. Our study also identified several nonmodifiable risk factors for increased LOS, including older age, female sex, and depression. These results are corroborated by prior studies in the shoulder arthroplasty literature.[12,17,19-21] Although the identification of such nonmodifiable risk factors has proved invaluable for risk stratification and predictive modeling of LOS and costs after shoulder arthroplasty, these patient characteristics are not easily addressed through interventional methods. In contrast, HL is a malleable trait that can be enhanced by providers.[2] Indeed, prior research has demonstrated that additional tailored patient education and resource provision improve patient comprehension, expectations, and satisfaction levels after hip and knee arthroplasty.[6,18,30,38]

In our study, we did not identify an association between HL and total hospitalization costs despite a significant association with LOS. Although seemingly discordant, these results may further suggest that the associations between LHL and increased LOS are clinically irrelevant. Alternatively, the group equivalence in hospitalization costs may be ascribed to additional factors known to largely drive the cost of inpatient shoulder arthroplasty. Menendez et al[23] previously identified implant charges to account for over half of total inpatient costs as calculated using TDABC whereas factors that vary the most between patients (postoperative personnel and medication charges) account for only 15% of total cost. In our study, the choice of implant

Table II Linear regression model for variables associated with length of stay after TSA

Parameter	Standardized β*	95% CI	*P* value
Age	0.18	0.002 to 0.03	.02†
Female sex	0.22	0.13 to 0.48	.001†
BMI	0.04	−0.01 to 0.02	.54
ASA score $>$ 2	0.13	−0.01 to 0.39	.07
Depression	0.15	0.04 to 0.45	.02†
National-percentile ADI	0.12	−0.001 to 0.01	.08
Medicare insurance	−0.01	−0.22 to 0.20	.93
Limited health literacy‡	0.14	0.02 to 0.42	.04†

TSA, total shoulder arthroplasty; *CI*, confidence interval; *BMI*, body mass index; *ASA*, American Society of Anesthesiologists; *ADI*, Area Deprivation Index.

* Standardized β coefficient, weighted to allow for comparison of relative strength of association with dependent variable between variables of interest.

† Statistically significant at $P < .05$.

‡ Defined as score $\leq$ 17 on Brief Health Literacy Screening Tool.

for each patient was predicated on individual demographic characteristics and shoulder pathology irrespective of the patient's level of HL, and the distribution of implant types did not significantly differ between groups. It is therefore possible that patients with LHL had only marginally higher costs, which were mostly attributable to postoperative personnel and medication charges. Such differences were not detected in our analysis, which may be due to a type II statistical error. We encourage the performance of larger confirmatory studies to determine whether HL also contributes to higher shoulder arthroplasty costs.

In our study, we report that patients with LHL undergoing inpatient shoulder arthroplasty present preoperatively with more severe symptoms. Sheth et al[37] similarly reported that among patients with primary glenohumeral osteoarthritis, those with lower socioeconomic status present with worse preoperative function and pain and increased opioid use. These findings collectively demonstrate that patients with LHL and socioeconomic deprivation may have increased difficulty with accessing care, resulting in delayed presentations with more advanced shoulder pathology.[37] Despite this, our study did not find associations between HL and immediate postoperative pain levels or inpatient opioid consumption. Although unexpected given the known associations between psychosocial factors and postoperative pain levels, this result is reassuring.[22] Our study was conducted at a high-volume orthopedic specialty hospital, with an interdisciplinary team dedicated to postoperative patient care. As such, rigorous standardized pain regimens have been implemented to minimize postoperative opioid consumption. Our hospital protocol consists of preoperative interscalene or subclavicular blocks and scheduled opioid-sparing analgesics for patients receiving shoulder arthroplasty. Although this patient population has not previously been studied, prior research has demonstrated lower pain levels and decreased opioid intake with similar protocols.[5,41]

The principal strengths of this study include the relatively large sample, the prospective assessment of HL using a validated instrument, and the application of TDABC methodology to evaluate the cost of care. However, our study is not without limitations. First, this study was conducted at a high-volume urban orthopedic specialty hospital serving predominantly white patients in the Northeastern United States, and all procedures were performed by a single surgeon. This may limit the generalizability of our results. Second, a large proportion of patients (70.4%) had perfect scores on the BHLST, and few (5.2%) had scores $\leq$ 12, which was an insufficient size for an analysis exclusive to patients with inadequate HL (BHLST score $\leq$ 12). To address this low variability in BHLST scores, a score threshold of 17 was used because this value has been shown to have high levels of sensitivity and specificity for detecting patients with inadequate or marginal HL.[7] Third, the decision to hospitalize patients for extended periods is largely driven by subjective provider and hospital practice styles. We attempted to decrease such bias by removing patients from the LOS analysis if they had Medicare insurance and had planned discharges to rehabilitation facilities, as the Centers for Medicare & Medicaid Services requires a hospital stay of 3 consecutive days to extend coverage to such extended-care facilities.[16] Fourth, shoulder arthroplasty costs must be linked to patient experience, quality of life, and functional outcomes to adequately assess the value of patients' care.[24] This is a subject of our future research.

Conclusion

LHL is commonplace among patients undergoing elective shoulder arthroplasty and is associated with greater preoperative symptom severity and activity intolerance. Its association with longer hospitalizations suggests that HL is an important factor to consider for postoperative disposition planning.

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