Increased health services use by severely obese patients undergoing emergency surgery: a retrospective cohort study

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Background: The aim of this study was to assess perioperative outcomes in obese patients undergoing emergency surgery.

Methods: We retrospectively reviewed the charts of all adult (> 17 yr) patients admitted to the acute care emergency surgery service at the University of Alberta Hospital between January 2009 and December 2011 who had a body mass index (BMI) of 35 or higher. Patients were divided into subgroups for analysis based on "severe" (BMI 35–39.9) and "morbid" obesity (BMI ≥ 40). Multivariate logistic regression was performed to identify predictors of in-hospital mortality after controlling for confounding factors.

Results: Data on 111 patients (55% women, median BMI 39) were included in the final analysis. Intensive care unit (ICU) support was required for 40% of patients. Postoperative complications occurred in 42% of patients, and 31% required reoperation. Overall in-hospital mortality was 17%. Morbidly obese patients had increased rates of reoperation (40% v. 23%, p = 0.05) and increased lengths of stay compared with severely obese patients (14.5 v. 6.0 d, p = 0.09). Age (odds ratio [OR] 1.08 per increment) and preoperative ICU stay (OR 12) were significantly associated with in-hospital mortality after controlling for confounding, but BMI was not.

Conclusion: Obese patients requiring emergency surgery represent a complex patient population at high risk for perioperative morbidity and mortality. Greater resources are required for their care, including ICU support, repeat surgery and prolonged ICU stay. Future studies could help identify predictors of reoperation and strategies to optimize nutrition, rehabilitation and resource allocation.

Contexte : Cette étude avait pour objet d'évaluer les résultats périopératoires chez des patients obèses soumis à une chirurgie d'urgence.

Méthodes : Nous avons passé en revue de manière rétrospective les dossiers de tous les patients adultes (> 17 ans) pris en charge par l'équipe de chirurgie d'urgence du Centre hospitalier de l'Université de l'Alberta entre janvier 2009 et décembre 2011 et dont l'indice de masse corporelle (IMC) était de 35 ou plus. Aux fins de l'analyse, les patients ont été répartis en 2 groupes selon qu'ils présentaient une obésité « grave » (IMC 35–39,9) ou « morbide » (IMC ≥ 40). Nous avons utilisé un modèle d'analyse de régression logistique multivariée pour reconnaître les prédicteurs de la mortalité perhospitalière après avoir tenu compte des facteurs de confusion.

Résultats : L'analyse finale a porté sur les données concernant 111 patients (55 % de femmes, IMC médian 39). Il a fallu faire appel à l'Unité des soins intensifs (USI) pour 40 % des patients. Des complications postopératoires sont survenues chez 42 % des patients et 31 % ont nécessité une réopération. Dans l'ensemble, la mortalité perhospitalière a été de 17 %. Les patients atteints d'obésité morbide ont présenté des taux plus élevés de réopération (40 % c. 23 %, p = 0,05) et des séjours hospitaliers plus longs comparativement aux patients souffrant d'obésité grave (14,5 c. 6,0 jours, p = 0,09). L'âge (rapport des cotes [RC] 1,08 par palier) et un séjour préopératoire à l'USI (RC 12) ont été significativement associés à la mortalité perhospitalière après contrôle des facteurs de confusion, mais non l'IMC.

Conclusion : Les patients obèses qui ont besoin d'une chirurgie urgente forment une population de patients complexe exposée à un risque élevé de morbidité et de mortalité périopératoires. Leurs soins requièrent plus de ressources, y compris recours à l'USI, reprise de la chirurgie et prolongation du séjour à l'USI. D'autres études pourraient aider à recenser les prédicteurs des réopérations et à trouver des stratégies d'optimisation de la nutrition, de la réadaptation et de l'attribution des ressources.

Obesity is a growing problem worldwide. According to the World Health Organization, the prevalence of obesity nearly doubled between 1980 and 2008. The most recent data indicate that 12% of the world's population is obese; the Americas have the highest prevalence of obesity at 26.7%. Obesity is associated with several comorbidities, including diabetes mellitus, dyslipidemia, ischemic stroke and ischemic heart disease. Worldwide, it is estimated that excess body weight (overweight or obese) is responsible for 2.8 million deaths and 35.8 million disability-adjusted life years lost per year.[1] Given these associations, obesity has been theorized to be a risk factor for surgery. Many studies have investigated the impact of obesity on outcomes following elective surgery across various disciplines. These studies assessed a broad range of outcomes, including complication rates, duration of surgery, blood loss, length of stay (LOS) in hospital, hospital costs, mortality and disease-specific outcomes. Overall, results are conflicting: some studies are equivocal,[2–4] some show worse outcomes[5–10] and others provide evidence of an "obesity paradox," wherein patients who are overweight or mildly obese have better outcomes than those with a healthy weight.[11–14] Studies assessing obesity and outcomes specifically within general surgery have been similarly inconclusive.[2,9,12]

While most studies have assessed the impact of obesity on outcomes following elective surgery, few studies published to date have investigated the impact of obesity on emergency surgery. Patients requiring emergency surgery constitute a different population than those undergoing elective surgery. Given the emergent need for intervention and the subsequently minimized opportunity for preoperative selection and optimization, this population represents a much broader demographic than elective patients, likely carrying a more clinically important burden of comorbid illness. For this study, we hypothesized that obesity would be associated with increased perioperative morbidity and subsequently longer LOS. Accordingly, our objectives were to determine whether morbid obesity (body mass index [BMI] ≥ 40) compared with severe obesity (BMI 35–39.9) has a significant impact on in-hospital or 30-day mortality in patients undergoing emergency surgery and a significant impact on perioperative complications or LOS in hospital and in the intensive care unit (ICU).

Methods

The reporting of this study follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for observational studies.[15] The health research ethics boards at the University of Alberta approved this study before commencement, with the requirement for individual informed consent being waived.

Design and setting

This study consisted of a retrospective chart review of obese patients admitted to the acute care emergency surgery service at the University of Alberta Hospital (Edmonton, Alta.) between Jan. 1, 2009, and Dec. 31, 2011.

Participants

Patients were selected based on the following inclusion criteria: need for urgent or emergent surgery, BMI of 35 or higher and age older than 17 years. For the purposes of this study, urgent surgery was considered to be any operation performed on a patient with an acute surgical condition who was admitted through the emergency department. These operations included, but were not limited to, exploratory laparotomy, cholecystectomy, incision and drainage/débridement, appendectomy and herniorrhaphy. Patients were excluded if they were younger than 18 years, had a BMI less than 35 or had elective surgery.

Variables

The exposure of interest was emergency surgery. Primary outcomes included complications, need for reoperation, admission to the ICU, LOS in hospital and in the ICU and mortality (in hospital and 30-d). For the purpose of this analysis, the patients were subdivided into 2 groups for comparison of outcomes: severe obesity (BMI 35–39.9) and morbid obesity (BMI ≥ 40). This subdivision based exclusively on BMI criteria allowed for assessment of and adjustment for potential confounders, such as age, sex or comorbidities.

Data sources and collection

Data were extracted from patient medical records and included age, sex, BMI, LOS, comorbidities, procedure required, duration of surgery, operative blood loss, intraoperative complications, perioperative complications and mortality. Comorbidities were subcategorized into "average" (e.g., hypertension, hyperlipidemia) and "high-risk" comorbidities (e.g., coronary artery disease or myocardial infarction, cerebrovascular disease, chronic renal failure, diabetes mellitus and congestive heart failure) using the Goldman risk index.[16] Perioperative complications were also subdivided according to severity based on the Clavien–Dindo classification system.[17]

Operational definitions

As per the Clavien–Dindo classification,[17]

- Grade 1 refers to any deviation from normal postoperative care not requiring specific pharmacological or procedural intervention;

- Grade 2 refers to any complication requiring pharmacological intervention;
- Grade 3 refers to any complication requiring surgical, endoscopic or radiological intervention; and
- Grade 4 refers to any life-threatening complication requiring ICU support.

Statistical analysis

We performed our statistical analysis using SPSS software version 19 (2010). In cases of missing data values, data were not replaced or estimated. Data were analyzed using descriptive statistics to characterize demographics and other clinical variables. Categorical variables were compared using the χ^2 test or Fisher exact test (if expected cell count < 5). For continuous variables, normally distributed variables are reported as means with standard deviations; these were compared using a Student *t* test. Non-normally distributed continuous data are reported as medians with interquartile ranges (IQRs); these were compared using the Wilcoxon rank sum test. Mortality was defined as a dichotomous outcome: deceased at hospital discharge or at 30 days. A 2-sided significance level of < 0.05 was used for all comparisons.

In order to control for variables that may confound the effect of BMI on in-hospital mortality, we performed a multivariable logistic regression analysis. The prespecified prognostic variables included age, sex, BMI, preoperative stay in the ICU and any high-risk comorbidity. One model was built using BMI as a categorical variable (BMI 35–39 v. BMI ≥ 40), and the second was built using BMI as a continuous variable. Model performance was assessed using the χ^2 statistic and area under the receiver operator curve (AUROC). Multivariate associations are reported as odds ratios (ORs) with 95% confidence intervals (CIs).

Results

Participants and descriptive data

Baseline characteristics of the 111 patients included in this cohort are shown in Table 1. The median age of these patients was 53 (IQR 17–85) years, and the median BMI was 39 (35–83). Fifty-five percent were women. Ninety-seven (87%) patients had at least 1 comorbidity, while 43 (39%) had at least 1 high-risk comorbidity. Admitting diagnoses included 48 patients (43%) admitted with bowel-related pathology, 23 (21%) with biliary disease, 5 (14%) with appendicitis, 17 (15%) with soft tissue infections (soft tissue abscess or necrotizing infection) and 8 (9%) with other diagnoses (trauma, peptic ulcer disease, intra-abdominal abscess or bleeding). Twenty-one patients (19%) were in the ICU preoperatively. The operations performed were exploratory laparotomy (35%), cholecystectomy (21%), appendectomy (14%), incision and débridement (16%), herniorrhaphy (13%) and other (1%).

Outcome data

Following surgery, 44 (40%) patients required ICU admission, and 34 (31%) patients required reoperation. Forty-seven (42%) patients had postoperative complications, 22 of which (20%) were severe (Clavien–Dindo grade 3/4). Overall median LOS was 9 (4–24) days. Seventy-five (68%) patients were discharged home, while 20 (18%) were discharged to another institution. Thirty-day mortality was 11% (n = 13), while overall in-hospital mortality was 17% (n = 19).

Univariate comparison of BMI groups (35–39.9 v. ≥ 40)

The results of our comparison between 61 patients with a BMI of 35–39.9 and 50 patients with a BMI of 40 or

Table 1. Demographic characteristics of 111 obese patients undergoing emergent surgery

Characteristic	No. (%) or median [IQR]
Age, yr	53 [17–85]
Sex, female	61 (55)
Body mass index	39 [35–83]
Preoperative diagnosis	
Biliary disease	23 (21)
Soft tissue infection	17 (15)
Appendicitis	15 (14)
Incarcerated/strangulated hernia	15 (14)
Ischemic bowel	11 (10)
Perforated viscus	10 (9)
Bowel obstruction	10 (9)
Other	10 (9)
Preoperative illness	
Presence comorbidities	96 (87)
No. of comorbidities	2 [1–4]
High-risk comorbidity*	43 (39)
In intensive care preoperatively	21 (19)
Operating room characteristics	
Duration of surgery, min.	90 [56–140]
Blood products	22 (20)
No. of postoperative complications	0 [0–2]
Postoperative complication	47 (42)
Wound-related	38 (34)
Respiratory	22 (20)
Sepsis	19 (17)
Gastrointestinal	15 (14)
Acute kidney injury	13 (12)
Other	22 (20)
Severe complication†	22 (20)
Postoperative intensive care	44 (40)
Reoperation	34 (31)
Hospital length of stay (median)	9 [4–24]
In-hospital mortality	19 (17)

IQR = interquartile range.
*High-risk comorbidities refers to the presence of 1 or more of the following: coronary artery disease/myocardial infarction, cerebrovascular disease, chronic renal failure, diabetes mellitus or congestive heart failure.
†Severe complications included complication requiring surgical, endoscopic or radiologic intervention or a life-threatening complication requiring intensive care support (Clavien–Dindo grade 3/4).

higher are shown in Table 2. Overall, there were no statistically significant differences in the demographic characteristics or comorbidities, including high-risk comorbidities ($p > 0.15$ for all comparisons). There were no significant differences in operating factors, including time in the operating theatre and requirement for blood products. Postoperatively, there were no differences in admission to or LOS in the ICU or in the number or severity of complications. While the difference in rates of reoperation did not reach statistical equivalence, there was a trend toward higher rates of reoperation among morbidly obese patients than in severely obese patients (BMI ≥ 40, 20 of 50 patients, 40% v. BMI 35–39.9, 14 of 61 patients, 23%, $p = 0.05$). There was also a significant increase in LOS for patients with a BMI of 40 or higher (median 14.5, IQR 6–39 v. median 6, IQR 3–15.5 d, $p = 0.009$). There were no significant differences in unadjusted in-hospital or 30-day mortality between the groups ($p > 0.30$ for both).

Multivariable analysis: predictors of in-hospital mortality

We performed multivariable logistic regression analysis on the cohort of 111 patients to determine if the probability of in-hospital mortality was affected by prespecified prognostic variables based on physiologic plausibility and variables that achieved a statistical significance of $p = 0.10$ on univariable logistic regression (Table 3). This model included the following variables: age, sex, preoperative ICU support and high-risk comorbidities. Using 2 separate models, BMI was treated as a binary variable in model 1 (BMI ≥ 40 v. BMI 35–39.9) and as a continuous variable in model 2. After controlling for confounding, neither a BMI of 40 or higher (model 1) or incremental increases in BMI (model 2) conferred a significant effect on in-hospital mortality (adjusted $p > 0.15$ for both). In model 1, variables that had a significant association with in-hospital

Table 2. Comparison of emergent surgical patients with severe (BMI 35–39) and morbid obesity (BMI ≥ 40)

	Group; no (%) or median [IQR]		
Characteristic	Severe, *n* = 61	Morbid, *n* = 50	*p* value
Age, yr	52 [37–64]	55 [42–63]	0.76
Sex, female	30 (49)	31 (62)	0.18
Comorbidities	2 [1–4]	3 [1–5]	0.14
Coronary artery disease	8 (13)	9 (18)	0.48
Congestive heart failure	6 (9.8)	2 (4)	0.29
Diabetes mellitus	15 (25)	18 (36)	0.19
Chronic renal failure	5 (8.1)	4 (8)	> 0.99
Stroke	1 (1.6)	4 (8)	0.17
Composite (any)	20 (33)	23 (46)	0.16
Operative factors			
Time in operating theatre, min.*	85 [54–135]	104 [57–156]	0.27
Blood products	11 of 60 (18)	11 (22)	0.63
Intraoperative complications			
None	52 (85)	43 (86)	0.90
Cardiovascular event	0	0	> 0.99
Bleeding	1 (16)	3 (6)	0.32
Injury to adjacent structure	5 (8.2)	3 (6)	0.72
Conversion to open procedure	3 (4.9)	1 (2)	0.41
Postoperative complications*	0 [0–1.5]	0 [0–2.25]	0.26
Clavien–Dindo Grade 3/4 complications	12 (20)	10 (20)	0.95
Reoperation	14 (23)	20 (40)	0.05
Patient in ICU			
Preoperatively	11 (18)	10 (20)	0.80
Postoperatively	21 (34)	23 (46)	0.22
Lengths of stay			
In intensive care*	0 [0–3]	0 [0–9.5]	0.19
In hospital*	6 [3–15.5]	14.5 [6–39]	0.009
Mortality			
In hospital	9 (15)	10 (20)	0.47
30 d	5 (8.2)	7 (14)	0.37

BMI = body mass index; ICU = intensive care unit; IQR = interquartile range.
*Continuous variables analyzed using nonparametric (Wilcoxon rank sum) methods.

mortality included age (OR 1.08 per increment, 95% CI 1.02–1.13) and preoperative stay in the ICU (OR 12.76, 95% CI 3.32–49.02). In model 2, age (OR 1.08 per increment, 95% CI 1.02–1.14) and preoperative stay in the ICU (OR 11.79, 95% CI 3.10–44.84) were significantly associated. Both models performed well (model 1 AUROC: 0.88, and model 2 AUROC: 0.89).

Discussion

Key results

In this study, obese patients (BMI > 35) had high rates of morbidity and mortality with emergency surgery. Postoperative complications were common (42%); a substantial number of patients required postoperative critical care (40%). In-hospital mortality was high (17%). Comparing patients with morbid obesity (BMI ≥ 40) to patients with severe obesity (BMI 35–39.9), morbidly obese patients were more likely to require reoperation (40% v. 23%) and had significantly longer LOS (14.5 v. 6 d). However, substantially higher BMI did not appear to impact in-hospital mortality, either on unadjusted analysis or after adjusting for confounding variables (both $p > 0.15$). Independent covariates associated with increased in-hospital mortality included advanced age (OR 1.08 per incremental year) and requirement for ICU care before surgery (OR 12).

Comparison with previous studies

There is a paucity of data on the outcomes of obese patients following emergency surgery. Many studies have assessed the outcomes of obese patients undergoing elective surgery with conflicting results. Wakefield and colleagues[8] found an increased risk of complications with obese patients undergoing intestinal surgery. However, in a study of Veterans Affairs surgical patients, Herrera and colleagues[2] found no difference in the rate of postoperative complications. Conversely, Mullen and colleagues[12] found evidence for an obesity paradox when they investigated 118 707 patients undergoing nonbariatric general surgery; the lowest mortality was in the overweight and moderately obese groups. The authors did, however, find increasing rates of wound infections with increasing BMI.[12]

Regarding emergency surgery, there is some evidence on outcomes from mixed BMI populations. Weissman and Klein[18] assessed the differences between emergency and elective postoperative patients requiring critical care. Emergency patients were found to have more severe pre-existing illnesses, required prolonged postoperative mechanical ventilation, required longer ICU stays and had higher mortality. Becher and colleagues[19] compared 25 770 patients undergoing emergency surgery with 98 867 patients undergoing nonemergent surgery and found significantly higher rates of complications and mortality in the emergent group (22.8% v. 14.2% and 6.5% v. 1.4%, respectively). These rates of complications and mortality are notably lower than that in our study population. Ingraham and colleagues[20] also assessed outcomes following emergency general surgery procedures in a mixed BMI population; their rates of morbidity and mortality are also significantly lower than ours.

Interpretation

We hypothesized that obesity would be associated with increased perioperative morbidity and LOS. Our results support this hypothesis in the form of higher rates of reoperation and longer LOS in morbidly obese patients. Furthermore, our rates of perioperative morbidity and mortality are significantly higher than those described above in the studies on mixed BMI populations. Thus, while our high rates of morbidity and mortality may be due in part to an increased burden of pre-existing illness (comorbidities and acute illness), it is likely they are also partially due to obesity.

The reasons behind the adverse effect of obesity on outcomes are not entirely clear. We theorize that some of the negative effect of obesity may be accounted for by malnutrition. While obesity involves excess caloric intake, several studies have shown a high prevalence of

Table 3. Predictors of in-hospital mortality in 111 patients with BMI greater than 35 who underwent urgent surgery

Predictor	Unadjusted*	*p* value	Model 1*	*p* value	Model 2*	*p* value
Age	1.07 (1.03–1.12)	0.001	1.08 (1.02–1.13)	0.009	1.08 (1.02–1.14)	0.008
Sex, female	1.99 (0.69–5.68)	0.20	1.37 (0.38–4.89)	0.63	1.25 (0.34–4.53)	0.74
ICU preoperatively	15.81 (4.96–50.35)	< 0.001	12.76 (3.32–49.02)	< 0.001	11.79 (3.10–44.84)	< 0.001
CHR	4.48 (1.55–12.93)	0.006	1.04 (0.26–4.08)	0.96	1.12 (0.28–4.43)	0.87
BMI > 40	1.44 (0.54–3.89)	0.47	1.812 (0.52–6.38)	0.35	—	—
BMI	1.03 (0.98–1.09)	0.22	—	—	1.05 (0.98–1.13)	0.17
χ^2	—	—	34.077	< 0.001	34.92	< 0.001
AUROC	—	—	0.88 (0.81–0.95)	< 0.001	0.89 (0.82–0.96)	< 0.001

AUROC = area under the receiver operator curve; BMI = body mass index; CHR = high-risk comorbidities; ICU = intensive care unit.
*Data presented as medians (with interquartile ranges).

micronutrient deficiencies in obese patients across a broad range of both vitamins and minerals.[21,22] Malnourished patients have slower healing, more complications, increased LOS, increased hospital costs and greater mortality.[23] Micronutrients may serve particularly important roles in recovery from illness, and supplementation of these micronutrients has been shown to reduce infectious complications, morbidity and mortality.[24] Thus, it is possible that premorbid micronutrient deficiencies, constituting malnutrition in obese patients, lead to impaired healing. A diminished ability to heal may explain the substantial need for ICU support, reoperation and the high mortality observed in our study.

The increased LOS we observed in morbidly obese patients is consistent with findings reported in the literature. Padwal and colleagues[25] examined the impact of severe obesity on rehabilitation time, LOS and hospital costs in a tertiary care rehabilitation hospital. When compared with controls who had a healthy BMI, the severely obese group had longer total LOS (37 v. 98 d, p = 0.028) and rehabilitation LOS (37 v. 56 d, p = 0.037). However, there were also significantly higher rates of diabetes, hypertension, renal failure and neurologic disease in the obese group. Another study from Australia found significant differences in LOS for obese patients; however, while medical patients stayed close to 4 days longer, surgically managed patients actually spent less time in hospital (–0.3 d, p = 0.029). The authors of that study hypothesized that this decrease in LOS was secondary to increased rates of interhospital transfer for surgical patients.[26] There are many potential factors contributing to the increased LOS that we observed. The increased rate of reoperation among morbidly obese patients likely extends the course of illness, the convalescence period and correspondingly, the LOS. In addition, given our relatively low rate of interhospital transfer, LOS is also probably extended by extra efforts and resources spent on mobilization and rehabilitation following acute surgical illness.

Limitations

The results of this study must be considered in the context of the following limitations. It is a retrospective, single-centre design, which predisposes results to possible selection bias. The data acquired are limited to what can be extracted from pre-existing, occasionally incomplete records. However, we believe there is substantial validity in studying this population in a retrospective fashion, as it would be difficult to study it prospectively. In addition, we did not have comparison data for patients with a healthy BMI who underwent emergent surgery owing to the nature of the acute care and emergency surgery registry that was used for this study. We attempted to address this by a comparison of BMI subgroups. Our subgroup comparison yielded several significant differences in outcomes attributable to increased BMI. We speculate that these differences would be further magnified in comparison to patients with a healthy BMI. Furthermore, to date this is the largest study published that specifically addresses emergent surgery in the obese population. Finally, given the small number of deaths in this study, we were able to adjust for only a limited number of covariates in our multivariable analysis based on previous literature and physiologic plausibility. We concede that there may be other confounding factors (known and unknown) for which we were unable adjust in our analysis (e.g., time to source control).

Generalizability

The results of this study are readily generalizable given the broad demographics of the patient population and could have important implications for the management of obese patients with acute surgical illnesses. To begin with, an improved understanding of the projected course in hospital will facilitate discussions with patients and their families regarding the clinical situation, interventions required (including the possibility of intensive care), prognosis and goals of care. Clinicians need to be vigilant for complications and the need for repeat operation. Addressing potential malnutrition in this population will be difficult. Studies have shown that preoperative enteral or parenteral nutrition improves outcomes in certain malnourished populations.[27,28] However, there is no evidence to support preoperative nutrition in this population specifically. Moreover, given that these patients are undergoing emergent procedures, there is unlikely to be time to allow for substantial preoperative nutritional optimization. Postoperative nutritional supplementation is also of uncertain benefit. Early parenteral therapy has not been shown to improve outcomes and may, in fact, worsen outcomes.[29] In addition, a recent randomized controlled trial assessing early enteral feeding after emergency abdominal surgery did not show any reduction in complications or LOS when compared with traditional enteral feeding.[30] The optimal approach to nutrition in this population remains unclear and further studies are needed.

In addition, a strong emphasis should be placed on early and aggressive mobilization of obese patients. An organized, multidisciplinary approach in this regard may help decrease the LOS of obese patients requiring emergency operations. Finally, these results have important implications on resource allocation issues given the requirement for multiple surgical procedures and the extended LOS.

Conclusion

Obese patients requiring emergency surgery represent a complex patient population at high risk for perioperative morbidity. Substantial resources are required for their care, including intensive care support, repeat surgical intervention and prolonged ICU stay. Future studies could help identify predictors of reoperation as well as strategies to optimize nutrition, rehabilitation and resource allocation.

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