Surgery Open Science 2 (2020) 45–49

Contents lists available at ScienceDirect

Surgery Open Science

journal homepage: https://www.journals.elsevier.com/surgery-open-science

Perioperative considerations in nonagenarians

Maria E. Tecos, MD [a], Brittany S. Kern, MD [b,e], Nathan A. Foje, MD [a,c], Marilyn L. Leif [c], Mitchell Schmidt, MD [d,f], Allie Steinberger, MD [e], Adam Bajinting [f], Keely L. Buesing, MD, FACS [a,c,*]

[a] University of Nebraska Medical Center, Department of Surgery, Omaha, NE
[b] Spectrum Health Michigan State University, Department of Surgery, Grand Rapids, MI
[c] University of Nebraska Medical Center, College of Medicine, Omaha, NE
[d] Washington University in St. Louis, Department of Surgery, St. Louis, MO
[e] Baystate Medical Center Department of Surgery, Hanover, MD
[f] St. Louis University, School of Medicine, St. Louis, MO

ARTICLE INFO

Article history:
Received 2 January 2020
Received in revised form 24 March 2020
Accepted 25 March 2020
Available online 26 April 2020

ABSTRACT

Objective: The nation's aging population presents novel perioperative challenges. Potential benefits of operative interventions must be scrutinized in relation to recoverable quality of life. The purpose of this study is to evaluate common risk calculators used for medical decision making in a nonagenarian patient population.
Methods: Retrospective medical record review was performed on patients 90 years or older who underwent operative interventions requiring anesthesia at a large academic medical center between January 1, 2013, and December 31, 2017. GraphPad 8.2.1 was used for statistical analysis.
Results: Significant differences were found when data were stratified by age for elective versus emergent cases (P value < .0001), ability to return to baseline function (P value = .0062), and mortality (P value < .0001). Significant differences were found in emergent and elective cases, ability to return to baseline function, readmissions, and mortality (all P values < .0001) when stratified by American Society of Anesthesiologists score. Ability of patients to return to baseline functionality after intervention was influenced by their preintervention level of functionality (P value = .0008). American College of Surgeons and Portsmouth Physiologic and Operative Severity Score for Enumeration of Mortality and Morbidity risk calculators underestimated the need for rehabilitation and overestimated mortality for this population (all P values < .0001).
Conclusion: Perioperative cares of the extreme geriatric population are complex and should be approached collaboratively. Rehabilitation and postoperative assistance resources should be assessed and used fully. Input from palliative care teams should be sought appropriately. End-of-life and escalation-of-care discussions should ideally be organized prior to emergent interventions. Frailty and risk calculators should be used and considered for formal implementation into the preoperative workflow.

INTRODUCTION

As our patient population ages, operating on nonagenarians has become more common [1–10]. The need for increased interdisciplinary guidelines for geriatric surgical care has been well established by the American College of Surgeons (ACS) [11]. These patients present unique challenges for surgeons, whose ultimate goal likely includes offering the best chance at returning to their baseline functional status. Because of this, the ACS has set out to delineate challenges and solutions to surgical hurdles unique to this demographic [12]. A handful of published studies have assessed elderly mortality rates after abdominal procedures, although these investigations were performed when nonagenarians themselves were less common [7–9].

Surgeons would also benefit from implementing metric systems to assess which patients will do well and which ones will not, and impart the wisdom to guide the decision to proceed with surgical intervention and the stressors entailed. The ACS Risk Calculator and the Portsmouth Physiologic and Operative Severity Score for Enumeration of Mortality and Morbidity (P-POSSUM) scores have been used to better guide these difficult decisions and serve as an adjunct to discussions with patients and their families. Racz et al published a similar study of the Canadian population in 2012 [6], and in 2014, Davis et al demonstrated higher than calculated morbidity in nonagenarians undergoing cardiac procedures [13]. The international community has highlighted this age group as requiring thoughtful considerations not only to promote appropriate patient selection for operative intervention but also to ensure safety in perioperative cares [14–18]. However, the data determining

* Corresponding author at: Keely Buesing, MD, FACS, University of Nebraska Medical Center, Department of Surgery, 983280 Nebraska Medical Center, Omaha, NE 68198-3280. Tel.: +1 402 559 9696; fax: +1 402 836 9459.
E-mail address: keely.buesing@unmc.edu (K.L. Buesing).

https://doi.org/10.1016/j.sopen.2020.03.004

the accuracy of these scoring systems in the nonagenarian population undergoing general surgical procedures in America have not been assessed in the last decade.

Here, we seek to assess the outcomes of nonagenarians who underwent procedures requiring general endotracheal anesthesia in an effort to better understand and delineate in what situations the benefits of surgery outweigh the risks in a population complicated by years of comorbidities and frailty. Emphasis will be placed upon a comprehensive approach using resources already widely available in general practice settings to further assist with planning the care of a unique population, such as risk and frailty calculators, physical and occupation therapists, and palliative care teams. In turn, it will also help to decrease stigma regarding operating on geriatric patients by providing evidence-based research to substantiate medical decision making.

METHODS

Approval for this study was obtained from the University of Nebraska Medical Center Institutional Review Board. A comprehensive retrospective medical record review was conducted on 555 patients who underwent any operative intervention requiring anesthesia at a large academic center between January 1, 2013, and December 31, 2017, who were 90 years of age or older at the time of the procedure. Thorough medical record review included data regarding patient demographics, presentation information, procedure performed, postoperative complications, length of stay, disposition at discharge, 1-month mortality, 6-month mortality, 1-year mortality, ACS Risk Calculator scores, P-POSSUM scores, elective or emergent case nature, functional status, living situation, ability to return to functional status, code status, change in code status, code status decision maker, palliative care consult, inpatient death, and American Society of Anesthesiologists (ASA) score, among other parameters. ACS Risk Calculator and P-POSSUM scores were calculated for each patient for whom the necessary parameters were obtainable. Each encounter of a procedure requiring anesthesia was identified as an isolated event; thus, individuals may be present multiple instances within the data set at different time points for additional emergent or elective procedures.

The resultant data set was inherently right skewed, with most patients being in their younger 90s, and thus did not follow a normal distribution. GraphPad Prism 8.2.1 was used to carry out nonparametric data analysis and assess data for descriptive statistics. Multiple Kruskal-Wallis and Mann-Whitney tests were carried out to determine the significance of various comparative permutations of the data. Graphical correlation of significant relationships as identified by Kruskal-Wallis testing was used to establish trends helpful in interpreting data significance.

RESULTS

A total of 555 qualifying patients were identified upon retrospective medical record review. Average patient age at time of intervention requiring anesthesia was 92.67 years old. Two hundred eleven patients were male, whereas 344 patients were female. Average ASA score was 3.16. Data were analyzed in multiple stratifications via Kruskal-Wallis and Mann-Whitney testing because of its non-normal distribution.

Age Stratification. When analyzed by patient age grouped into categories of below and above age 95 years, 59% of cases were emergent, whereas 41% of cases were elective, for those under 95 years. Comparatively, 83% of cases were emergent and 17% were elective for those over age 95 years (*P* value < .0001, Fig. 1).

A patient's ability to return to prior level of function was assessed by comparing documentation regarding living situation, status of independence, and discharge disposition. If a patient lived a lifestyle that did not require assistance preoperatively but did require assistance postoperatively, the patient was categorized as unable to return to the prior level of function. Conversely, if the patient was able to return to their preoperatively lifestyle with the same amount of assistance postoperatively, the patient was deemed as able to return to their prior level of function. Sixty-eight percent of patients under 95 years old were unable to return to prior function, whereas 29% were able to regain prior functionality. In the over–95 years old grouping, 79% were unable to return to prior function, whereas 20% were able to do so (*P* value = .0062, Fig 1, *B*). Functional status was not available for every patient in the data set.

Three percent of patients in the under–95 years age grouping died prior to discharge, whereas 97% of those under 95 years old survived to discharge. Ten percent of those over 95 years died prior to discharge, whereas 90% survived (*P value* <.0001, Fig. 1, *C*).

ASA Stratification. Further analysis was done by stratifying the data per ASA score. ASA1 is defined as a healthy patient, ASA2 is a patient with mild systemic disease, ASA3 is a patient with severe systemic disease that is a constant threat to life, ASA4 is a patient with incapacitating systemic disease that is a constant threat to life, ASA5 is a moribund patient unexpected to survive without operative intervention, and ASA6 is a patient who has been declared as brain dead undergoing organ procurement. Emergent cases accounted for 0%, 59%, 64%, and 63% of interventions for patients classified as ASA1, ASA2, ASA3, and ASA4, respectively; the remainder of cases in each group were deemed to be elective (*P value* <.0001, Fig. 2, *A*).

The ability of patients in each ASA score category to return to their level of preoperative function was also assessed; however, data regarding function status were not available for each patient. A total of 0%, 24%, 29%, and 24% of patients were able to return to their previous level of

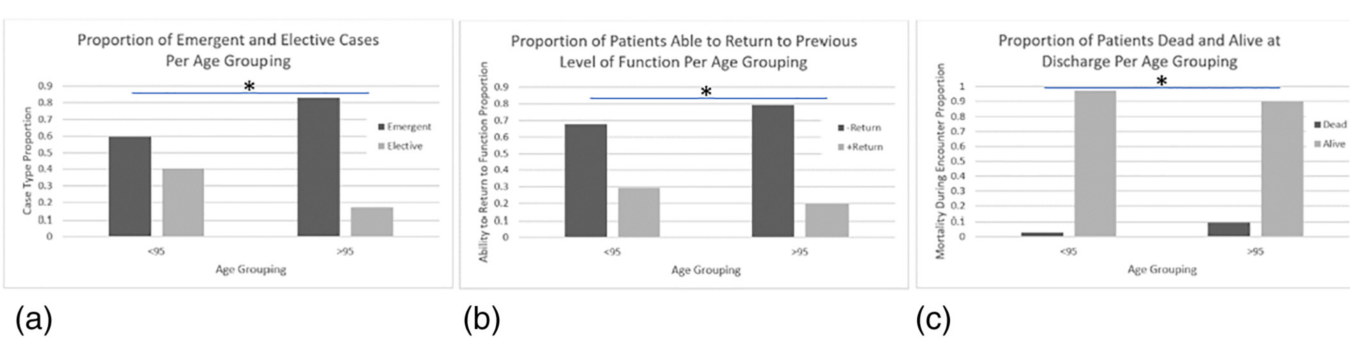

Fig. 1. A, Proportion of emergent and elective cases grouped by patient age under or over 95 years; *P value* <.0001. Emergent cases under 95 years old, $n = 281$; over 95 years old, $n = 68$. Elective cases under 95 years old, $n = 192$; over 95 years old, $n = 14$. B, Proportion of patients able to return to prior level of function grouped by patient age under or over 95 years; *P value* = .0062. Patients under 95 years old unable to return to prior function, $n = 320$; over 95 years old, $n = 65$. Patients under 95 years old able to return to prior function, $n = 138$; over 95 years old, $n = 16$. C, Proportion of patients dead and alive at time of discharge grouped by patient age under or over 95 years; *P value < .0001. Patients under 95* years old dead at time of discharge, $n = 14$; over 95 years old, $n = 8$. Patients under 95 years old alive at time of discharge, $n = 459$; over 95 years old, $n = 74$.

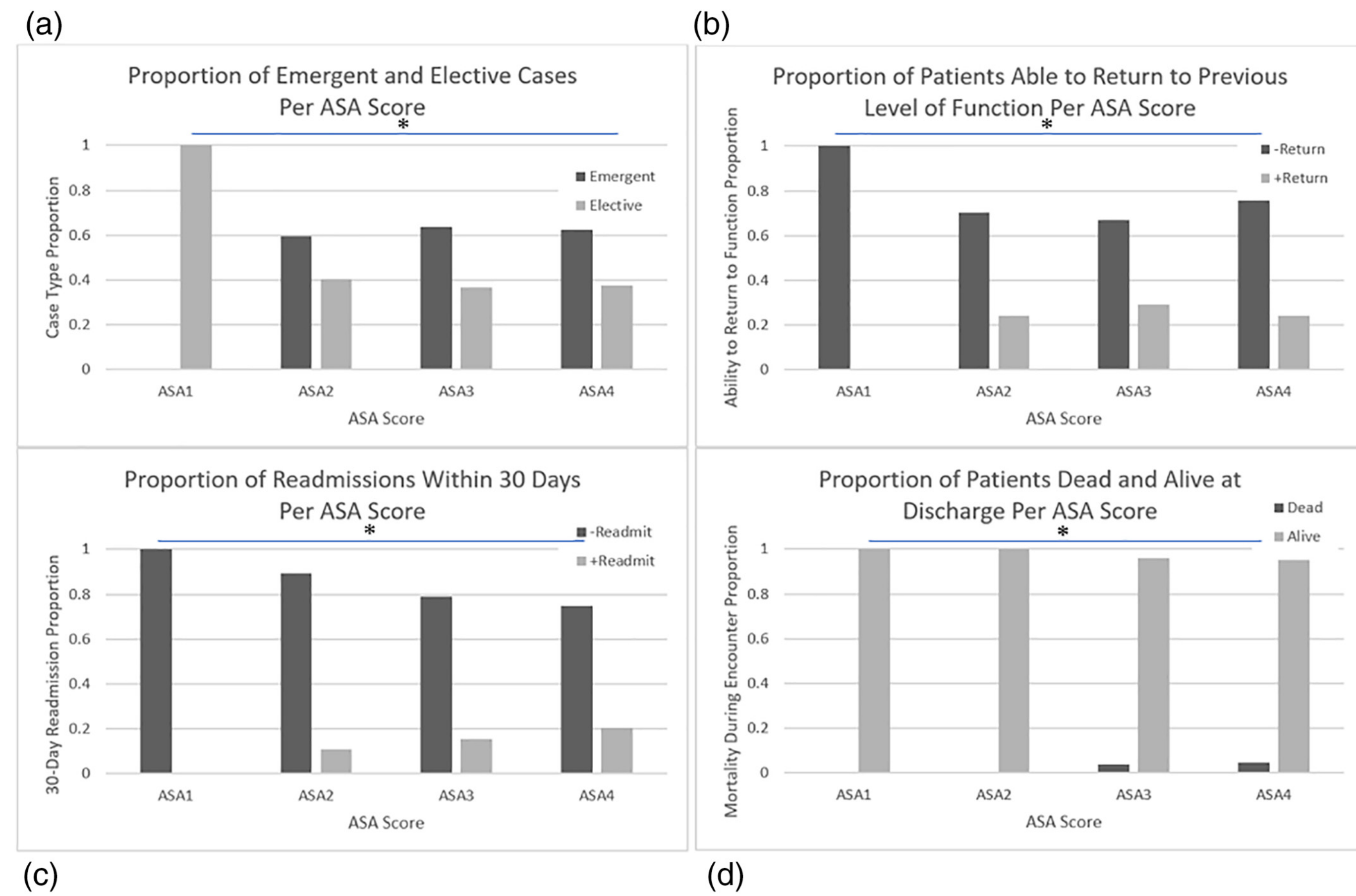

Fig. 2. A, Proportion of emergent and elective cases grouped by patient ASA score; *P value* <.0001. Number of emergent cases in ASA 1–4, respectively: 0, 22, 247, and 80. Number of elective cases in ASA 1–4, respectively: 1, 15, 142, and 48. B, Proportion of patients able to return to prior level of function grouped by patient ASA score; *P value < .0001. Number of patients unable to regain baseline function in ASA 1–4, respectively: 1, 26, 261, and 97. Number of patients able to regain baseline function in ASA 1–4, respectively: 0, 9, 114, and 31. C, Proportion of patients readmitted to hospital system within 30* days of discharge grouped by patient ASA score; *P value < .0001. Number of successful discharges in ASA 1–4, respectively: 1, 33, 308, and 96. Number of readmissions in ASA 1–4, respectively: 0, 4, 61, and 26. D, Proportion of patients dead and alive at discharge grouped by patient ASA score; P value < .0001. Number of deaths at discharge in ASA 1–4, respectively: 0, 0, 16, and 6. Number of patients alive at discharge in ASA 1–4, respectively: 1, 37, 373, and 122.*

function, whereas 100%, 70%, 67%, and 76% of patients were unable to return to their previous level of function in ASA score categories 1 through 4, respectively (*P value* <.0001, Fig. 2, *B*).

A *readmission* was defined as a subsequent admission to a hospital tracked within the electronic medical record (EMR) associated with the hospital system where the study was performed within 30 days of discharge from the encounter during which the intervention under anesthesia was performed. This was not available for each patient and could not account for instances where the patient may have been taken to a hospital outside of the health system in question. A total of 0%, 11%, 16%, and 20% of patients classified as ASA1, ASA2, ASA3, and ASA4, respectively, had subsequent readmissions within the hospital system within 30 days from their original discharge (*P value* <.0001, Fig. 2, *C*).

The proportion of patients who died prior to discharge in ASA grouping 1 through 4 was 0%, 0%, 4%, and 5% (*P value* <.0001, Fig. 2, *D*).

Functional Status. Preoperative functional status was assessed by surveying physical therapy and occupational therapy designations and recommendations. When this was not available, documentation from the patient, family, or referring facility was used. Functional status was not available for every patient. The level of postoperative assistance recommended for patient disposition by the physical and occupational therapy teams was used to designate each patient's postoperative functional status. If multiple recommendations were given during an inpatient stay, the assessment closest to discharge (which would be used as the patient's disposition plan) was considered. Determination if patients were able to return to prior level of function was made by assessing if they required more or less assistance or resources compared to their preoperative designation at discharge. Twenty-six percent of patients who were deemed independent were able to return to their prior state of living without any additional assistance compared to

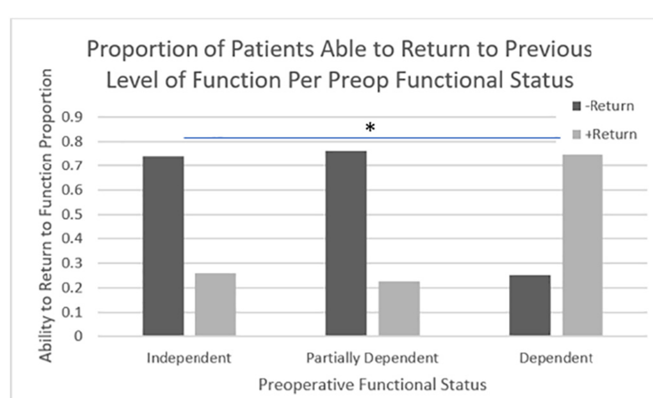

Fig. 3. Proportion of patients able to return to prior level of function grouped by preoperative functional status; *P value* = .0008. Previously independent patients unable to return to prior functionality, $n = 234$; able to regain functionality, $n = 82$. Previously partially dependent patients unable to return to prior functionality, $n = 141$; able to regain functionality, $n = 42$. Previously dependent patients unable to return to prior functionality, $n = 10$; able to regain functionality, $n = 30$.

23% of partially dependent patients and 75% of dependent patients (*P value* = .0008, Fig. 3). Partially dependent and dependent patients were deemed unable to return to prior level of function if they required more assistance than they already had in place prior to their intervention requiring anesthesia; that is, 76% of partially dependent and 25% of dependent patients required more resources at discharge.

Palliative Care Consult. Palliative care consults were ordered on 7% of all patients reviewed. Thirty-six percent of patients who died during their admission had palliative care consult. Eleven percent of patients had a code status change either escalating or deescalating cares during admission. Twenty percent of patients who had a formal palliative care consult in place died prior to discharge, whereas 3% of those without a palliative care consults died prior to discharge (*P value* <.0001, Fig. 4).

Risk Calculator Predictions. ACS and P-POSSUM values were calculated when able; however, the parameters necessary for these calculations were not available for each patient, or their procedure may not have been within the test database. Mann-Whitney tests were carried out to analyze statistically significant differences between groups. An ACS score was able to be calculated for 60% of patients, and a P-PPOSUM score was able to be calculated for 77% of patients. The average ACS-predicted rehabilitation score was 48%, whereas 64% of patients actually required postoperative rehabilitation services (*P value* <.0001, Fig. 5, *A*). The average ACS-predicted mortality was 7%, and the average P-POSSUM–predicted mortality was 13%. A statistically significant difference was shown when each of these was compared against the actual observed mortality of 4% (ACS-predicted mortality versus actual mortality *P value* <.0001, P-POSSUM–predicted mortality versus actual mortality *P value* <.0001, Fig. 5, *B*).

DISCUSSION

We do acknowledge that other frailty, morbidity, and mortality calculators do exist, some of which are specific to certain subspecialties of surgery, such as urology, head and neck surgery, surgical oncology, orthopedic surgery, colorectal surgery, cardiothoracic surgery, and neurosurgery. Surgical subspecialty risk calculators and frailty scores have outperformed generalized surgical risk calculators upon direct comparison [13,16,18–22]. The 5-element modified frailty index, which includes diabetes, chronic obstructive pulmonary disease, hypertension requiring medication, congestive heart failure, and functional status, has been found to be a strong predictor of adverse postoperative events [23]. Independent analysis of the ACS calculator has also demonstrated inaccuracies regarding its ability to reliably predict patient length of stay [24]. The Risk Analysis Index has been found to be a helpful adjunct in addition to the ACS score because of its ability to leverage patient frailty as an identifier for potential surgical prehabilitation [25]. Furthermore, use of a self-identified functionality scale was a better predictive tool for adverse outcomes when combined with the ACS calculator than the frailty phenotype [26].

The nature of a retrospective medical record review is limited by the completeness of the medical record, particularly in the setting of a single-institution study. As mentioned previously, the ACS and P-POSSUM scores were unable to be calculated for all patients, as some were missing data or the type of procedure the patient underwent was not within the calculator tool. Furthermore, readmission instances could only be tracked within the health system's own EMR system. It is possible that these patients had other encounters outside of the health system studied. It also proved quite difficult to accurately assess elements such as complications because of the expansive variety of ways in which those instances were recorded within the EMR. It was also impossible to verify if any risk calculators were consistently used in preoperative assessments of this population. Although documentation of this was present in a very small number of surgical consultation notes, it is possible that some surgeons may not have documented calculations that were indeed performed or, rather, relied on the gestalt of their career experience. There may be opportunity to standardize risk stratification as part of the preoperative EMR workflow, particularly in the elective outpatient setting.

We also acknowledge that there are confounding variables within this population. Certainly, these patients have bodies that have dealt with decades of multiple comorbidities, making them inherently frailer than many younger patients. However, they have also outlived their peers and thus may have some physiological advantage regarding their overall age-adjusted fitness. Per this analysis, the ACS and P-POSSUM calculators did overestimate the predicted mortality of this population while underestimating the need for rehabilitation. This may be a result of more aggressive cares as medicine has advanced and a trend toward patients to maintain functionality and independence in extreme old age. This may be an opportunity for more liberal use of palliative care teams to set goals for the postoperative course (or operative decision-making process) with the patient and family beyond end-of-life cares.

This study was limited by several significant factors. The data set was overall inherently skewed, with more patients in the younger end of the nonagenarian pool. The data set also contained more women than men. Because of the non-normal distribution of the data, nonparametric data analysis tools were used. This limited the ability to interpret exactly which relationships within each comparison held the most significance, but was able to demonstrate significant trends across compared groups of data. Although the overall data set was adequately powered, the microanalyses within the subgroupings of course had a smaller number of patients, which limit the clinical application of the analyzed trends. For example, only 1 patient had an ASA score of ASA 1; however, it would be unusual to find a large number of ASA 1 patients in the nonagenarian population.

In conclusion, medical and surgical cares of the extreme geriatric population are complex and should be approached in a multidisciplinary fashion. Teams involved in medical decision making should have extensive and thorough conversations regarding the patient's wishes for escalation of cares and end-of-life planning, ideally in the outpatient setting, prior to an emergent encounter. It would be beneficial to have the input of palliative care teams as appropriate.

Routinely collected preoperative patient data parameters readily available via EMR review have been previously used to construct simple frailty indices to predict adverse surgical outcomes independent of risk and frailty calculators [27]. Rather than recommend the use of a single risk calculator alone, we propose that the addition of a frailty index (such as the 5-element modified frailty index) or patient functionality

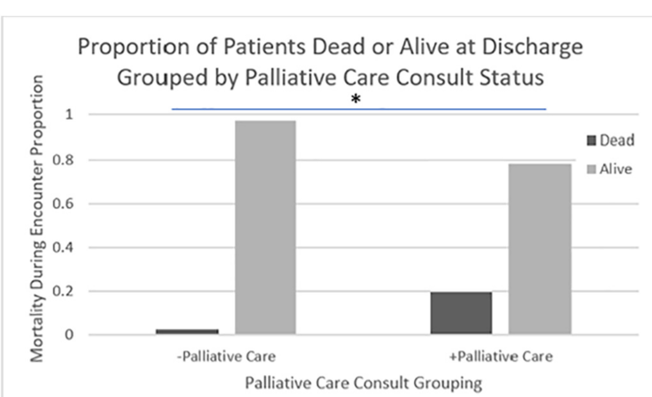

Fig. 4. Proportion of patients dead and alive at discharge grouped by palliative care consult status; *P value* <.0001. Number of patients deceased (14) and alive (501) at time of discharge who did not receive a palliative care consult. Number of patients deceased (8) and alive (32) at time of discharge who did receive a palliative care consult.

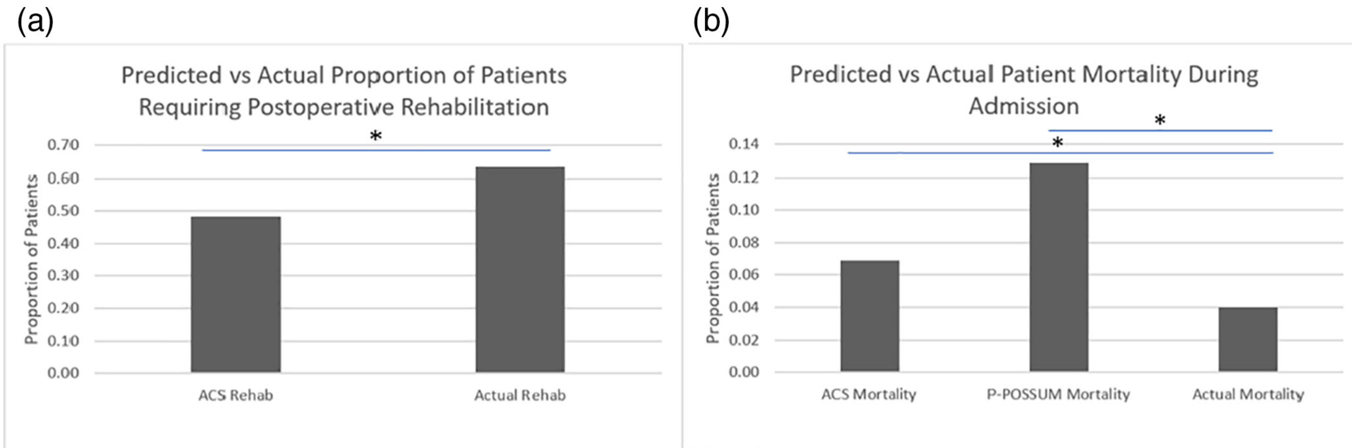

Fig. 5. A, ACS rehabilitation prediction versus proportion of patients who actually required postoperative rehabilitation; *P value* <.0001. ACS rehabilitation score averaged for 331 patients for whom it could be calculated. A total of 343 of 540 patients required some element of postoperative rehabilitation. B, ACS mortality prediction and P-POSSUM mortality prediction versus actual patient mortality. ACS versus actual, *P value* < *.0001*; P-POSSUM versus actual, *P value* < *.0001. ACS mortality score averaged for 331 patients for whom it could be calculated. P-POSSUM mortality score averaged for 421 patients for whom it could be calculated.* Twenty-two of 555 patients died during their operative encounter.

self-assessment can be leveraged to augment the baseline use of a perioperative risk calculator, such as the ACS score, in this particularly vulnerable population. Additionally, risk calculators specific to subspecialty surgery should be used as available. Finally, available postoperative recovery resources should be assessed for assistance in the rehabilitation period.

Author Contributions

We verify that all listed authors contributed to the manuscript in ways worthy of authorship.

Conflict of Interest

No author has any known conflict of interest.

Funding Sources

No funding was used to carry out this study.

References

[1] Afilalo J, Mottillo S, Eisenberg MJ, et al. Addition of frailty and disability to cardiac surgery risk scores identifies elderly patients at high risk of mortality or major morbidity. Circ Cardiovasc Qual Outcomes 2012;5(2):222–8. https://doi.org/10.1161/circoutcomes.111.963157.
[2] Arenal JJ, DeTeresa G, Tinoco C, et al. Abdominal surgery in nonagenarians: short-term results. Surg Today 2007;37:1064–7.
[3] Bilimoria KY, Liu Y, Paruch JL, et al. Development and evaluation of the universal ACS NSQIP surgical risk calculator: a decision aide and informed consent tool for patients and surgeons. Journal of the American College of Surgeons 2013;217(5):833–42 e3 https://doi.org/10.1016/j.jamcollsurg.2013.07.385.
[4] Blansfield JA, Clark SC, Hofmann MT, et al. Alimentary tract surgery in the nonagenarian: elective vs. emergent operations. J Gastrointest Surg 2004;8:539–42.
[5] Prytherch DR, Whiteley MS, Higgins B, et al. POSSUM and Portsmouth POSSUM for predicting mortality. Physiological and operative severity score for the enumeration of mortality and morbidity. Br J Surg 1998;85:1217–20.
[6] Racz J, Dubois L, Katchky A, Wall W. Elective and emergency abdominal surgery in patients 90 years of age or older. Can J Surg 2012;55(5):322–8. https://doi.org/10.1503/cjs.007611.
[7] Rigberg D, Cole M, Hiyama D, et al. Surgery in the nineties. Am Surg 2000;66:813–6.
[8] Warner MA, Hosking MP, Lobdell CM, Offord KP, Melton LJ. Surgical procedures among those greater than or equal to 90 years of age. A population-based study in Olmsted County, Minnesota, 1975–1985. Ann Surg 1988;207(4):380–6.
[9] Zerbib P, Kulick JF, Lebuffe G, et al. Emergency major abdominal surgery in patients over 85 years of age. World J Surg 2005;29:820–5.
[10] Neuman M, Bosk C. The redefinition of aging in American surgery. Milbank Q 2013;91(2):288–315.
[11] Russell MM, et al. Improving quality in geriatric surgery a blueprint from the American College of Surgeons. Bull Am Coll of Surg 2016;101:22–8.
[12] Robinson TN, Rosenthal RA. The ACS NSQIP geriatric surgery pilot project: improving care for older surgical patients. Bull Am Coll Surg 2014;99(10):21–3.
[13] Davis JP, et al. Nonagenarians undergoing cardiac surgery. J Card Surg 2014;29:600–4.
[14] Desserud KF, Veen T, Soreide K. Emergency general surgery in the geriatric patient. BJS 2016;103:e52–61.
[15] Farina-Castro R, et al. Five-year survival after surgery in nonagenarian patients. Geriatr Gerontol Int 2017;17:2389–95.
[16] Assmann A, et al. Cardiac surgery in nonagenarians: not only feasible, but also reasonable? Interact Cardiovasc Thorac Surg 2013;17:340–4.
[17] Partridge JSL, et al. The impact of pre-operative comprehensive geriatric assessment on postoperative outcomes in older patients undergoing scheduled surgery: a systematic review. Anesthesia 2014;69:8–16.
[18] Soma T, et al. Colorectal resection in nonagenarians: effectiveness of laparoscopic surgery. Asian J Endosc Surg 2014;7:222–6.
[19] Mascarella MA, et al. Evaluation of a preoperative adverse event risk index for patients undergoing head an neck cancer surgery. JAMA Otolarungol Head Neck Surg 2019 Apr;145(4):345–51.
[20] Mascarella MA, et al. Preoperative risk index among patients undergoing thyroid or parathyroid surgery. JAMA Otolaryngol Head Neck Surg 2020;146(1):7–12.
[21] Choi et al. A novel risk calculator to predict outcome after surgery for symptomatic spinal metastases; use of a large, prospective patient database to personalize surgical management. Eur J Cancer 2019 Jan;107:28–36.
[22] Sathianathen NJ, Jarosek S, Lawrentschuk N, Bolton D, Konety BR. A simplified frailty index to predict outcomes after radical cystectomy. Eur Urol Focus 2019 Jul;5(4):658–63.
[23] Subramaniam S, Aalberg JJ, Soriano RP, Divino CM. New 5-factor modified frailty index using American College of Surgeons NSQIP data. J Am Coll Surg 2018 Feb;226(2):173–81.
[24] Stocker B, et al. Predicting length of stay for trauma and emergency general surgery patients. Am J Surg 2020 Feb. [In press ahead of print].
[25] van der Windt DJ, et al. Preoperative risk analysis index for frailty predicts short-term outcomes after hepatopancreaticobiliary surgery. HPB (Oxford) 2018 Dec;20(12):1181–8.
[26] Kapoor A, et al. Self-reported function more informative than frailty phenotype in predicting adverse postoperative course in older adults. J Am Geriatr Soc 2017 Nov;65(11):2522–8.
[27] Amrock LG, Neuman MD, Lin HM, Deiner S. Can routine preoperative data predict adverse outcomes in the elderly? Development and validation of a simple risk model incorporating a chart-derived frailty score. J Am Coll Surg 2014 Oct;219(4):684–94.