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The Urgent Surgery Elderly Mortality risk score: a simple mortality score

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ABSTRACT

Introduction: an increasing number of elderly patients undergo urgent abdominal surgery and this population has a higher risk of mortality. The main objective of the study was to identify mortality-associated factors in elderly patients undergoing abdominal surgery and to design a mortality scoring tool, the Urgent Surgery Elderly Mortality risk score (the USEM score).

Patients and methods: this was a retrospective study using a prospective database. Patients > 65 years old that underwent urgent abdominal surgery were included. Risk factors for 30-day mortality were identified using multivariate regression analysis and weights assigned using the odds ratios (OR). A mortality score was derived from the aggregate of weighted scores. Model calibration and discrimination were judged using the receiver operating characteristics curves and the Hosmer-Lemeshow test.

Results: in the present study, 4,255 patients were included with an 8.5% mortality rate. The risk factors significantly associated with mortality were American Society of Anesthesiologists (ASA) score, age, preoperative diagnosis (OR: 37.82 for intestinal ischemia, OR: 5.01 for colorectal perforation, OR: 6.73 for intestinal obstruction), surgical wound classification and open or laparoscopic surgery. A risk score was devised from these data for the estimation of the probability of survival in each patient. The area under the ROC curve (AUROC) for this score was 0.84 (95% CI: 0.82-0.86) and the AUROC correct was 0.83 (0.81-0.85)

Conclusions: a simple score that uses five clinical variables predicts 30-day mortality. This model can assist surgeons in the initial evaluation of an elderly patient undergoing urgent abdominal surgery.

Key words: Urgent abdominal surgery. Elderly patients. Mortality score.

INTRODUCTION

Elderly population is rapidly increasing in Spain and is defined as people older than 65 years (1). In fact, more than a half of urgent surgery in the United States is performed in elderly patients (2,3). In 2011, there were 34.2% of elderly patients from a total population of 46,815,316 in Spain. Population growth projections predict a rate of 40.5% of patients older than 65 years in a total population of 46,037,605 in Spain.

It has long been recognized that advanced age increases risk of mortality and morbidity after urgent surgery, due to the decrease in physiological reserve and associated comorbidities (3,4). In fact, patients undergoing urgent procedures have a higher rate of mortality (5-7). Havens et al. described 24,068 events (12.55%) of mortality in urgent surgery cases, compared with 42,597 events (2.66% in mortality rate) in elective procedures ($p < 0.001$) (8).

Several urgent mortality prediction models have been developed that can be used in both urgent and elective surgery. The most important ones are the Physiological and Operative Severity Score for the Enumeration of Mortality (POSSUM) (9), the Portsmouth- Physiological and Operative Severity Score for the Enumeration of Mortality (P-POSSUM) (10), the Acute Physiology And Chronic Health Evaluation II (APACHE II) (11), the DONATI (12), the Simple Prognostic Index (SPI) (13), the Emergency Surgery Score (ESS) (14), the Emergency Surgery

Acuity Score (ESAS) (15) and the Surgical Outcome Risk Tool (SORT) (16). However, prediction models are either unreliable, have a small sample size, are not validated, cannot be calculated preoperatively, are specific only to the geriatric population, are not designed for abdominal surgery or are designed for elective surgeries (17-19).

The aim of this study was to identify the preoperative and intraoperative variables that predict mortality and design a new mortality score for urgent abdominal surgery (the USER score).

PATIENTS AND METHODS

The study included elderly patients who underwent urgent abdominal surgery from 1994 to 2016 at the Complejo Hospitalario de Navarra, Spain. A retrospective analysis of a prospectively collected database was performed. The patient and operation-related data were retrieved retrospectively from the electronic medical records of the hospital or were prospectively included. All patients without a complete register of risk factors were excluded. The Institutional Review Board approved this study and all study participants provided informed consent.

The following variables were identified: age, gender, American Society of Anesthesiologists (ASA) score, diagnosis, surgical wound classification, open or laparoscopic surgery (as described in the surgical record) and 30-day mortality. Thirteen diagnostic categories were defined: appendicitis, intestinal obstruction, acute cholecystitis, intestinal ischemia, colorectal obstruction, polytrauma, colorectal perforation, complicated peptic ulcer, soft tissue abscess, incarcerated hernia, hepatobiliary pancreatic surgery (including patients with hepatic bleeding, acute cholangitis or acute pancreatitis that require urgent surgical treatment but excluding acute cholecystitis), low gastrointestinal bleeding (LGIB) and intra-abdominal abscess. Wound classification was defined using the Center for Disease Control and the criteria of the Prevention's adaptation of the American College of Surgeons (20). As described in the surgical record, this was divided into three categories: a) clean and clean-contaminated; b) contaminated; and c) dirty/infected.

The variables of age, gender, ASA, preoperative diagnosis, wound class and an open or laparoscopic procedure were included in the univariate and multivariate analysis. The study outcome of interest was 30-days mortality.

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Firstly, the relationship of each variable with the outcome (postoperative mortality) was analyzed using the Chi-square test for the categorical variables and t-test for continuous variables. Secondly, a multivariate logistic model was built that included the statistically significant variables (p-value < 0.05). A new mortality prediction score was created using the beta coefficients from the final multivariate model (21). Model discrimination was evaluated using the area under the receiver operator characteristics curve, which determines the ability of the test to correctly classify those with and without the outcome. The model calibration was judged using the Hosmer-Lemeshow test, which evaluates the degree of correspondence between the estimated probabilities of mortality produced by a model and the actual mortality experience of the patients. The bootstrap resampling model (150 samples) was used to internally validate our prediction model, which resulted in the corrected area under the ROC curve (AUROC). All statistical analyses were performed using SPSS v22.0.0.

RESULTS

In the present study, 4,255 patients > 65 years old undergoing urgent abdominal surgery in a tertiary hospital were registered from January 1994 to January 2016. Fifty-eight (1.3%) patients were excluded with an incomplete record (Fig. 1). Demographic variables are summarized in table 1 and a total of 1,879 (44.2%) patients were female and 2,376 (55.8%) were male. The mean age was 76.55 years old (range 65 to 96 years old) and the median was 77 (± 7.19). In addition, 1,880 were ASA III (44.8%) and 80 (1.9%) were ASA V. The most common class of surgical procedure was contaminated surgery (1,703, 40%). A total of 3,730 (87.7%) procedures were open procedures and 525 (12.3%) were laparoscopic procedures. Acute cholecystitis was the most frequent diagnosis using a laparoscopic procedure in 373 (47%) cases, followed by acute appendicitis in 75 (16%). The most common diagnosis was acute cholecystitis in 792 (18.6%) cases, incarcerated hernia in 663 (15.6%), acute appendicitis in 463 (10.9%) and intestinal obstruction in 449 (10.4%). About half of the patients with intestinal ischemia died during the postoperative period and was therefore the diagnosis most related with mortality. The overall mortality was 366 (8.6%).

Table 2 summarizes the multivariate analysis and predictor factors of 30-day mortality. The variables with a lower risk of mortality such as ASA I, acute appendicitis, clean/clean-contaminated and laparoscopic surgery were considered as reference variables. The variables associated with mortality were age ($p < 0.001$, OR: 1.04; 95% CI: 1.02-1.05), high ASA class (ASA V $p < 0.001$ OR: 23.10; 95% CI: 6.51-81.94), ASA IV ($p < 0.001$ OR: 9.61; 95% CI: 2.95-31.27) and diagnosis ($p < 0.001$). The diagnoses most related with mortality were intestinal ischemia (OR: 37.82; 95% CI: 17.87-80.07), hepatobiliary pancreatic surgery (OR: 10.43; 95% CI: 4.55-23.92) and LGIB (OR: 8.31; 95% CI: 3.50-19.74). Incarcerated hernia, intra-abdominal abscess, acute cholecystitis and soft tissue abscess were not significantly related to mortality. Dirty or infected surgery were significantly predictive of 30-day postoperative mortality and open surgery was related to the outcome (OR: 2.59; 95% CI: 1.31-5.16). Gender was the only variable that was not associated with mortality (p 0.84).

A new score was created based on the beta coefficients derived from the multivariate model, which allowed us to calculate the probability of 30-day mortality and was called the USEM score. The score was computed using the values presented in table 3 and the probability estimated by applying the logistic function to the score value.

In general, the inclusion of only significant variables could overestimate beta coefficients and underestimate standard errors of a multivariate regression model. However, one variable was left out in our study and there was no significant change in the coefficients after the exclusion of this variable.

The USEM score had a good discriminative ability and the AUROC was 0.84 (95% CI: 0.82-0.86) (Fig. 2). The resulting model was well calibrated according to the Hosmer- Lemeshow test ($p = 0.33$, X- square: 9.16). The corrected AUROC was 0.83, 95% CI: 0.81-0.85 after bias correcting using bootstrap resampling.

DISCUSSION

There are many predictor models described in the literature that are applicable in either urgent or emergency surgery. All of them describe the combination of preoperative or intraoperative variables to estimate the probability of 30-day mortality. However, there are multiple prediction rules for the same problem and there is no prediction model for urgent abdominal surgery. It is essential to understand that human clinical judgment is not enough to predict adverse events and new predictor models will assist surgeons to improve the clinical decision making.

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Liao et al. analyzed in 2003 the resistance to adopt prediction models in the medical practice, and suggested that such tools may not be thought of as user friendly and therefore, may not take into account the continual and dynamic way in which humans gather clinical information. Their final reason for low implementation of clinical prediction rules was the sheer number of models available. Thus, if multiple prediction rules exist for the same problem, identifying the best one is difficult (22).

Many scoring systems have been designed to predict mortality; the first one was the POSSUM score described by Copeland (9). The initial trial of POSSUM found that the equation over-predicted deaths by a factor greater than 2 and in order to correct this over-prediction, they created a new formula called P-POSSUM (10). P-POSSUM was derived from a multivariable logistic regression analysis and contained 18 variables; 12 of these were measured preoperatively and six at hospital discharge. Two separate equations for morbidity and mortality were developed and validated. P-POSSUM has been used in a larger number of recent studies and has been found to have a moderate to high discriminant accuracy (10,23). P-POSSUM has been used to compare mortality rates after surgery between patients in the United States of America (USA) and United Kingdom (UK) (24). The greatest limitation is the number of variables required and the fact that it cannot be used preoperatively when the patient should ideally be aware of the operative risk.

Donati (12) developed a new model in 2004 that was easy to calculate and only used preoperative variables. Age, ASA grade, mode of surgery (elective, urgency or emergency) and severity of the surgery were included in the model. It is well calibrated and has a high discriminant accuracy. However, only 103 patients undergoing urgent or emergent surgery were included in the original study from a total of 1,936. In fact, if we analyze all the data, the mortality rate is 29% in patients undergoing urgent surgery and 40% in patients undergoing emergency surgery. However, the mortality published in the literature is between 8% and 30% (16,25,26).

The Surgical Risk Scale (SRS) (27,28) is a mortality predictor model that is easy to use and only considers preoperative variables. The AUROC is 0.94, compared to 0.84 for the POSSUM score or 0.84 for USEM. However, there are some limitations. Firstly, the surgical severity coding is not intuitive and some familiarity with the British United Provident Association system would be required for bedside estimation, unless a reference manual was available.

Secondly, it has only been validated in single-center studies within the UK. Thirdly, it is a predictor model designed for many surgical specialties and not exclusively for abdominal surgery. Finally, recent studies demonstrated that the SRS overestimated mortality, particularly in higher risk patients (17).

The Surgical Outcome Risk Tool (SORT) (16) is a risk stratification tool comprised of six preoperative variables, which are validated internally to predict 30-day mortality in adults. It is a validated multi-centric model that includes surgical procedures from vascular, thoracic gastrointestinal and urology surgery, 21.8% of which were urgent or emergent procedures. Six preoperative variables are included to calculate the probability of mortality.

A new scoring tool comprised of five variables was developed and validated internally to predict 30-day mortality in elderly patients undergoing urgent abdominal surgery. For the USEM to be used routinely, the speed and simplicity of collecting variables are important features to be considered. The variables included in the USEM score are directly or indirectly included in other previously validated models. First of all, the age of the patient was described in many papers as an independent risk factor for mortality (12,14,16,29,30). Secondly, ASA grading (proposed in 1941) is a widely used measure of perioperative risk. ASA grade has been associated with postoperative outcomes in many articles (12,16,27). However, four previous studies found a lack of accuracy when tested in heterogeneous cohorts (16,23). Thirdly, the diagnosis is related to the severity of surgery, which is also included in the SRS, POSSUM, P-POSSUM, DONATI and SORT scores (9,10,20,24,27,31). Fourth, the surgical wound classification is associated with the peritoneal soiling, which is included in the most relevant surgical prediction models, and open or laparoscopic surgery, which is included in the coding schedules of the British United Provident Association (BUPA) or AXA specialist Procedures Codes (32).

The USEM score was developed using both preoperative and intraoperative variables. However, intraoperative variables, such as surgical wound classification and open or laparoscopic procedure, are easily predictable before surgery due to the improvement of the new diagnostic methods such as computerized tomography (CT) scan. In fact, 95% of patients that underwent urgent surgery in the Complejo Hospitalario de Navarra during 2017 had a diagnosis by ultrasound or CT-scan. These diagnostic methods allowed us to presume the two intraoperative variables with accuracy. The improvement of the diagnostic methods can assist surgeons in the use of our score in the preoperative scenario. In the future, it will be necessary to compare the correlation between intraoperative variables and accuracy of the ultrasound and CT-scan used as predicting tools of the intraoperative variables.

There is no predictor model that is specific for urgent abdominal surgery. A novel risk tool was developed to predict 30-day mortality in adults undergoing urgent abdominal surgery and this model is more feasible to apply at the bedside than the POSSUM score, as it does not require blood results. This new model for assessing operative risk is easy to calculate and to use. We expect that the use of this model will be helpful in the clinical decision-making in elderly patients undergoing urgent abdominal surgery. These patients have a reduced physiological reserve and increased comorbidity that is associated with a higher susceptibility to disability and postoperative mortality after urgent abdominal surgery (18,19,33). The USEM model could be useful to facilitate an appropriate risk assessment and informed decision-making. Furthermore, it may also provide an objective assessment to inform and support that decision, which is made jointly by patients, their family and physicians. This could be particularly used in unfavorable situations, in which surgical interventions become futile treatment.

Our study has some limitations that must be acknowledged. Firstly, it is a retrospective analysis of a prospectively collected database in a single center, from 1994 to 2016. Over the last 20 years, both medical and surgical treatments have evolved, such as the improvement in antibiotic therapy related to a decrease in mortality. As a consequence, we analyzed the mortality per year and there were no significant differences. Secondly, this model was internally validated and external validation via a multi-centric study will be required in the future. Thirdly, it is not a preoperative predictor model, although we can predict the intraoperative variables with the diagnostic methods at our disposal. Fourthly, if we are evaluating mortality in elderly patients, it would be necessary to take into account some characteristics unique to the geriatric population, such as functional status and frailty. We are working on a prospective study that includes frailty and the functional status as collected variables. In the last years, studies in various surgical populations have identified frailty as an independent risk factor for mortality (18,30,34,35). The question of the best clinical tool for the assessment of frailty remains unanswered and the majority of available tools were not designed to be applied in a clinical context such as the Fried scale (36), Rockwood and the

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Frailty score from the Canadian Study of Health and Ageing (CSHA) (37). Finally, outcomes such as postoperative complications, discharge destination or frailty after surgery, which have been performed in other studies were not assessed.

CONCLUSIONS

The main factors related to 30-day mortality in elderly patients after urgent abdominal surgery were age, ASA, preoperative diagnosis, surgical wound classification and open or laparoscopic surgery. We developed a new scoring tool to predict 30-day mortality with five variables. The USEM score was well calibrated (x square 14.17) and had a high discriminatory capacity (AUROC 0.84). The model was validated internally (AUROC corrected: 0.83), although further validation testing is required. The USEM score could be used in conjunction with clinical judgment to aid in decision-making and facilitate informed consent in elderly patients undergoing urgent abdominal surgery. We cannot forget that these models are methods that aid decision-making, without replacing it, as surgical decisions must also take into account the wishes of the patients and their families, as well as ethical considerations.

REFERENCES

1. Abellán García A, Pujol Rodríguez R. Un perfil de las personas mayores en España, 2016. Indicadores estadísticos básicos. Madrid: Informes Envejecimiento en red nº 14; 2016. Available from: http://envejecimiento.csic.es/documentos/documentos/enred-indicadoresbasicos16.pdf

2. Torrance ADW, Powell SL, Griffiths EA. Emergency surgery in the elderly: challenges and solutions. Open Access Emerg Med;7:55-68. DOI: 10.2147/OAEM.S68324

3. Partridge JSL, Harari D, Dhesi JK. Frailty in the older surgical patient: a review. Age Ageing 2012;41(2):142-7. DOI: 10.1093/ageing/afr182

4. Gazala S, Tul Y, Wagg A, et al. Quality of life and long-term outcomes of octo- and nonagenarians following acute care surgery: a cross sectional study. World J Emerg Surg 2013;8:23. DOI: 10.1186/1749-7922-8-23

5. Gale SC, Shafi S, Dombrovskiy VY, et al. The public health burden of emergency general surgery in the United States: a 10-year analysis of the Nationwide Inpatient Sample - 2001 to 2010. J Trauma Acute Care Surg 2014;77(2):202-8. DOI:

10.1097/TA.0000000000000362

6. Shah AA, Latif A, Zogg CK, et al. Emergency general surgery in a low-middle income health care setting: determinants of outcomes. Surgery 2016;159(2):641-9. DOI: 10.1016/j.surg.2015.08.004

7. Ingraham AM, Cohen ME, Bilimoria KY, et al. Comparison of 30-day outcomes after emergency general surgery procedures: potential for targeted improvement. Surgery 2010;148(2):217-38. DOI: 10.1016/j.surg.2010.05.009

8. Havens JM, Peetz AB, Do WS, et al. The excess morbidity and mortality of emergency general surgery. J Trauma Acute Care Surg 2015;78(2):306-11. DOI: 10.1097/TA.0000000000000517

9. Copeland GP, Jones D, Walters M. POSSUM: a scoring system for surgical audit. Br J Surg 1991;78(3):355-60. DOI: 10.1002/bjs.1800780327

10. 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(9):1217-20. DOI: 10.1046/j.1365-2168.1998.00840.x

11. Jones DR, Copeland GP, De Cossart L. Comparison of POSSUM with APACHE II for prediction of outcome from a surgical high-dependency unit. Br J Surg 1992;79(12):1293-6. DOI: 10.1002/bjs.1800791216

12. Donati A, Ruzzi M, Adrario E, et al. A new and feasible model for predicting operative risk. Br J Anaesth 2004;93(3):393-9.

13. Abbas SM, Kahokehr A, Mahmoud M, et al. The Simple Prognostic Index (SPI): a pathophysiologic prognostic scoring tool for emergency laparotomy. J Surg Res 2010;163(2):e59-65. DOI: 10.1016/j.jss.2010.04.054

14. Nandan AR, Bohnen JD, Sangji NF, et al. The Emergency Surgery Score (ESS) accurately predicts the occurrence of postoperative complications in emergency surgery patients. J Trauma Acute Care Surg 2017;83(1):84-9. DOI: 10.1097/TA.0000000000001500

15. Sangji NF, Bohnen JD, Ramly EP, et al. Derivation and validation of a novel Emergency Surgery Acuity Score (ESAS). J Trauma Acute Care Surg 2016;81(2):213-20. DOI: 10.1097/TA.0000000000001059

16. Protopapa KL, Simpson JC, Smith NCE, et al. Development and validation of the Surgical Outcome Risk Tool (SORT). Br J Surg 2014;101(13):1774-83. DOI: 10.1002/bjs.9638

17. Fukuda N, Wada J, Niki M, et al. Factors predicting mortality in emergency abdominal surgery in the elderly. World J Emerg Surg 2012;7(1):12. DOI: 10.1186/1749-7922-7-12

18. Joseph B, Zangbar B, Pandit V, et al. Emergency general surgery in the elderly: too old or too frail? J Am Coll Surg 2016;222(5):805-13. DOI: 10.1016/j.jamcollsurg.2016.01.063

19. Kim S, Han H-S, Jung H, et al. Multidimensional frailty score for the prediction of postoperative mortality risk. JAMA Surg 2014;149(7):633-40. DOI: 10.1001/jamasurg.2014.241

20. Garner JS. CDC guideline for prevention of surgical wound infections, 1985. Supersedes guideline for prevention of surgical wound infections published in 1982 (originally published in November 1985). Revised. Infect Control 1986;7(3):193-200. DOI: 10.1017/S0195941700064080

21. Adams ST, Leveson SH. Clinical prediction rules. BMJ 2012;344:d8312. DOI: 10.1136/bmj.d8312

22. Liao L, Mark DB. Clinical prediction models: are we building better mousetraps? J Am Coll Cardiol 2003;42(5):851-3. DOI: 10.1016/S0735-1097(03)00836-2

23. Moonesinghe SR, Mythen MG, Das P, et al. Risk stratification tools for predicting morbidity and mortality in adult patients undergoing major surgery: qualitative systematic review. Anesthesiology 2013;119(4):959-81. DOI: 10.1097/ALN.0b013e3182a4e94d

24. Bennett-Guerrero E, Hyam JA, Shaefi S, et al. Comparison of P-POSSUM risk-adjusted mortality rates after surgery between patients in the USA and the UK. Br J Surg 2003;90(12):1593-8. DOI: 10.1002/bjs.4347

25. Al-Temimi MH, Griffee M, Enniss TM, et al. When is death inevitable after emergency laparotomy? Analysis of the American College of Surgeons National Surgical Quality Improvement Program database. J Am Coll Surg 2012;215(4):503-11. DOI: 10.1016/j.jamcollsurg.2012.06.004

26. Arenal JJ, Bengoechea-Beeby M. Mortality associated with emergency abdominal surgery in the elderly. Can J Surg 2003;46(2):111-6.

27. Sutton R, Bann S, Brooks M, et al. The Surgical Risk Scale as an improved tool for risk-adjusted analysis in comparative surgical audit. Br J Surg 2002;89(6):763-8. DOI:

10.1046/j.1365-2168.2002.02080.x

28. Gil-Bona J, Sabaté A, Bovadilla M, et al. Valor de los índices de Charlson y la escala de riesgo quirúrgico en el análisis de la mortalidad operatoria. Cir Esp 2010:174-9. DOI: 10.1016/j.ciresp.2010.05.012

29. Al-Temimi MH, Griffee M, Enniss TM, et al. When is death inevitable after emergency laparotomy? Analysis of the American College of Surgeons National Surgical Quality Improvement Program database. J Am Coll Surg 2012;215(4):503-11. DOI: 10.1016/j.jamcollsurg.2012.06.004

30. Carpenter CR, Shelton E, Fowler S, et al. Risk factors and screening instruments to predict adverse outcomes for undifferentiated older emergency department patients: a systematic review and meta-analysis. Acad Emerg Med 2015;22(1):1-21. DOI: 10.1111/acem.12569

31. Berríos-Torres SI, Umscheid CA, Bratzler DW, et al. Centers for Disease Control and Prevention Guideline for the Prevention of Surgical Site Infection, 2017. JAMA Surg 2017;152(8):784-91. DOI: 10.1001/jamasurg.2017.0904

32. AXA PPP Healthcare. Specialist Procedure Codes. Cited Dec 11th, 2017. Available from: https://online.axappphealthcare.co.uk/SpecialistForms/SpecialistCode.mvc?source=published

33. Joseph B, Zangbar B, Pandit V, et al. Mortality after trauma laparotomy in geriatric patients. J Surg Res 2014;190(2):662-6. DOI: 10.1016/j.jss.2014.01.029

34. Partridge JSL, Harari D, Dhesi JK. Frailty in the older surgical patient: a review. Age Ageing 2012;41(2):142-7. DOI: 10.1093/ageing/afr182

35. Goeteyn J, Evans LA, De Cleyn S, et al. Frailty as a predictor of mortality in the elderly emergency general surgery patient. Acta Chir Belg 2017;1-6. DOI: 10.1080/00015458.2017.1337339

36. Fried LP, Tangen CM, Walston J, et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci 2001;56(3):M146-56. DOI: 10.1093/gerona/56.3.M146

37. Hewitt J, Moug SJ, Middleton M, et al. Prevalence of frailty and its association with mortality in general surgery. Am J Surg 2015;209(2):254-9. DOI:

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Table 1. Patient demographics (n = 4,255)

Age	
– Mean	76.55 years old (range 65-96 years old)
Gender	
– Female	1,879 (44.2%)
– Male	2,376 (55.8%)
ASA	
– ASA I	209 (4.9%)
– ASA II	1,330 (31.3%)
– ASA III	1,880 (44.2%)
– ASA IV	700 (16.7%)
– ASA V	80 (1.9%)
Surgical wound classification	
– Clean/clean-contaminated	1,160 (27.6%)
– Contaminated	1,693 (40.3%)
– Dirty or infected	1,344 (32.02%)
Surgical procedure	
– Open surgery	3,730 (87.7%)
– Laparoscopic procedure	525 (12.3%)

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Table 2. Multivariate model

Variable	Categories	OR (95% CI)	p-value
Age	years	1.04 (1.02, 1.05)	< 0.001
Diagnosis	Appendicitis	Reference	< 0.001
	Soft tissue abscess	1.04 (0.42, 2.58)	
	Acute cholecystitis	1.65 (0.74, 3.67)	
	Intra-abdominal abscess	1.70 (0.49, 5.87)	
	Incarcerated hernia	2.69 (1.25, 5.79)	
	Complicated peptic ulcer	3.04 (1.25, 7.43)	
	Colorectal obstruction	5.08 (2.40, 10.73)	
	Colorectal perforation	5.18 (2.49, 10.78)	
	Intestinal obstruction	6.73 (3.22, 14.06)	
	Polytrauma	7.75 (2.57, 23.39)	
	Other	8.08 (3.65, 17.88)	
	LGIB	8.31 (3.50, 19.74)	
	Hepatobiliary pancreatic surgery	10.43 (4.55, 23.92)	
	Intestinal Ischemia	37.82 (17.87, 80.07)	
ASA	ASA I	Reference	< 0.001
	ASA II	1.72 (0.52, 5.73)	
	ASA III	3.73 (1.15, 12.09)	
	ASA IV	9.61 (2.95, 31.27)	
	ASA V	23.10 (6.51, 81.94)	
Surgical wound classification	Clean/clean-contaminated	Reference	< 0.001
	Contaminated	1.59 (1.16, 2.19)	
	Dirty or infected	2.48 (1.70, 3.49)	
Open or laparoscopic surgery	Laparoscopic surgery	Reference	0.007
	Open surgery	2.59 (1.31, 5.16)	

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LGIB: low gastrointestinal bleeding; ASA: American Society of Anesthesiologists.

Table 3. The USEM formula

Age x 0.036
Diagnosis – Acute appendicitis x 0
– Soft tissue abscess x 0.037
– Acute cholecystitis x 0.500
– Intra-abdominal abscess x 0.531
– Incarcerated hernia x 0.988
– Complicated peptic ulcer x 1.113
– Colorectal obstruction x 1.625
– Colorectal perforation x 1.646
– Intestinal obstruction x 1.907
– Polytrauma x 2.048
– Other x 2.089
– LGIB x 2.117
– Hepatobiliary pancreatic surgery x 2.345
– Intestinal ischemia x 3.633

ASA – ASA I x 0
– ASA II x 0.545
– ASA III x 1.317
– ASA IV x 2.263
– ASA V x 3.140

Surgical wound classification – Clean/clean-contaminated x 0
– Contaminated x 0.469
– Dirty or infected x 0.911

– Laparoscopic surgery x 0

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– Open surgery x 0.953

USEM: -9.32 + Age + Diagnosis + ASA + Wound class + Open/Laparoscopic surgery. Probability of 30-day mortality = exp (USEM)/(1+ exp [USEM])

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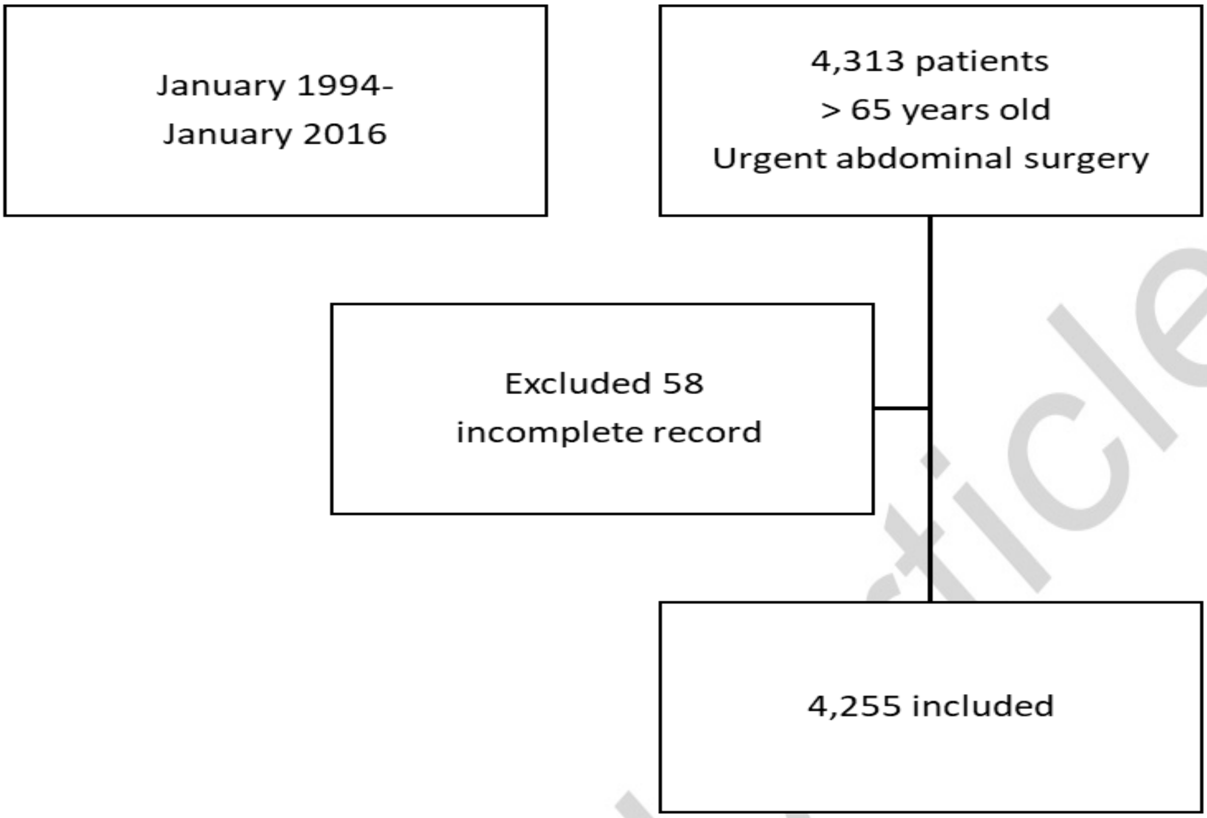

Fig. 1. Flowchart of patient selection.

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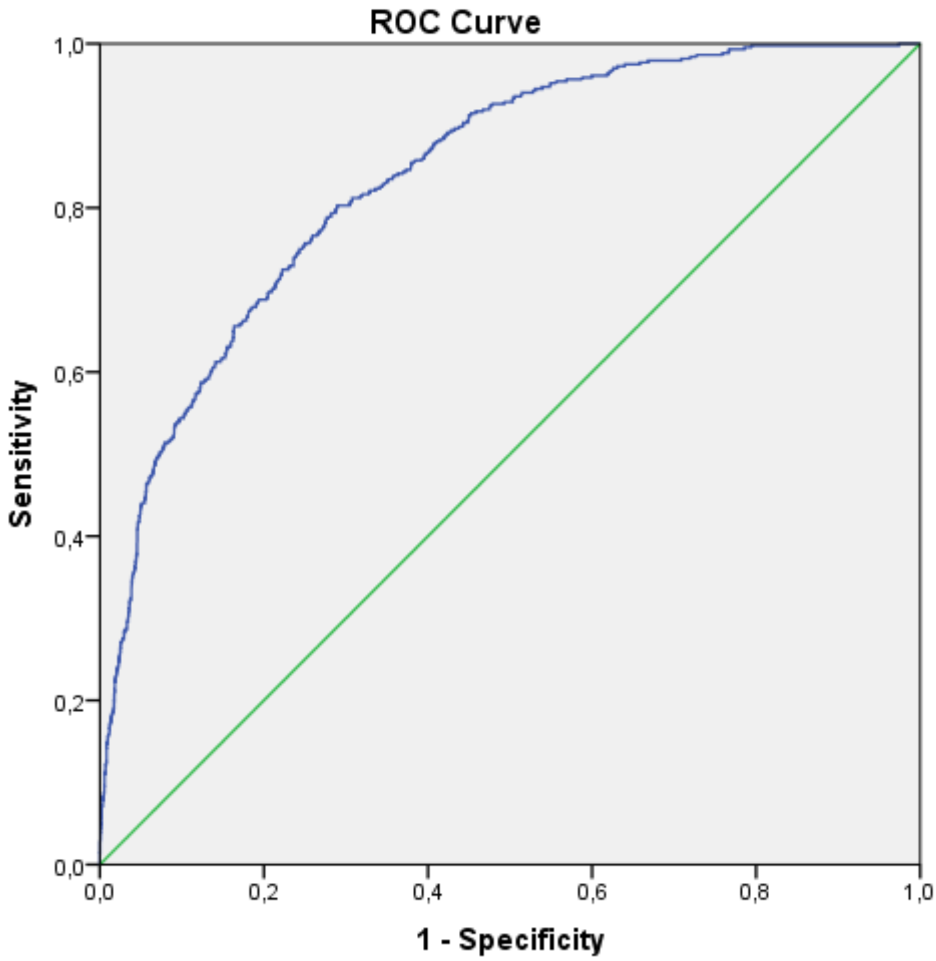

Fig. 2. AUROC of 0.84 (95% CI: 0.82-0.86). New predictor model (the USEM score). Discriminative capacity.