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2024 Clinical Practice Guideline Update by the Infectious Diseases Society of America on Complicated Intra-abdominal Infections: Risk Assessment in Adults and Children

Robert A. Bonomo,[1] Anthony W. Chow,[2] Fredrick M. Abrahamian,[3] Mary Bessesen,[4] E. Patchen Dellinger,[5] Morven S. Edwards,[6] Ellie Goldstein,[7] Mary K. Hayden,[8] Romney Humphries,[9] Keith Kaye,[10] Brian Potoski,[11] Jesús Rodríguez Baño,[12] Robert Sawyer,[13] Marion Skalweit,[14] David R. Snydman,[15] Pranita D. Tamma,[16] Katelyn Donnelly,[17] Dipleen Kaur,[17] Jennifer Loveless[17]

[1]Medical Service and Center for Antimicrobial Resistance and Epidemiology, Louis Stokes Cleveland Veterans Affairs Medical Center, University Hospitals Cleveland Medical Center, Cleveland, Ohio, USA, and Departments of Medicine, Pharmacology, Molecular Biology, and Microbiology, Case Western Reserve University, Cleveland, Ohio, USA, [2]Department of Medicine, University of British Columbia, Vancouver, British Columbia, Canada, [3]Department of Emergency Medicine, Olive View-UCLA Medical Center, Sylmar, California, USA, and David Geffen School of Medicine at UCLA, Los Angeles, California, USA, [4]Veterans Affairs Eastern Colorado Health Care, Aurora, Colorado, and Division of Infectious Diseases, University of Colorado School of Medicine, Aurora, Colorado, USA, [5]Department of Surgery, University of Washington, Seattle, Washington, USA, [6]Division of Infectious Diseases, Department of Pediatrics, Baylor College of Medicine, Houston, Texas, USA, [7]RM Alden Research Laboratory, Santa Monica, California, USA, [8]Division of Infectious Diseases, Department of Medicine, Rush University Medical Center, Chicago, Illinois, USA, [9]Division of Laboratory Medicine, Department of Pathology, Microbiology and Immunology, Vanderbilt University Medical Center, Nashville, Tennessee, USA, [10]Division of Allergy, Immunology and Infectious Diseases, Rutgers Robert Wood Johnson Medical School, New Brunswick, New Jersey, USA, [11]Department of Pharmacy and Therapeutics, University of Pittsburgh School of Pharmacy, Pittsburgh, Pennsylvania, USA, [12]Division of Infectious Diseases and Microbiology, Department of Medicine, Hospital Universitario Virgen Macarena, University of Seville, Biomedicines Institute of Seville-Consejo Superior de Investigaciones Científicas, Seville, Spain, [13]Department of Surgery, Western Michigan University School of Medicine: Western Michigan University Homer Stryker MD School of Medicine, Kalamazoo, Michigan, USA, [14]Department of Medicine and Biochemistry, Case Western Reserve University School of Medicine, Cleveland, Ohio, USA, [15]Division of Geographic Medicine and Infectious Diseases, Tufts Medical Center, Boston, Massachusetts, USA, [16]Department of Pediatrics, Johns Hopkins University School of Medicine, Baltimore, Maryland, USA, [17]Clinical Affairs and Practice Guidelines, Infectious Diseases Society of America, Arlington, Virginia, USA

ABSTRACT. This paper is part of a clinical practice guideline update on the risk assessment, diagnostic imaging, and microbiological evaluation of complicated intra-abdominal infections in adults, children, and pregnant people, developed by the Infectious Diseases Society of America. In this paper, the panel provides a recommendation for risk stratification according to severity of illness score. The panel's recommendation is based upon evidence derived from systematic literature reviews and adheres to a standardized methodology for rating the certainty of evidence

and strength of recommendation according to the GRADE (Grading of Recommendations, Assessment, Development and Evaluation) approach.

Key words. intra-abdominal infection; risk stratification; severity of illness; guideline

In adults and children with complicated intra-abdominal infection, which severity of illness score for risk stratification calculated within 24 hours of hospital or intensive care unit (ICU) admission best predicts 30-day or in-hospital mortality?

Recommendation: Risk stratification according to severity of illness is important for management of complicated intra-abdominal infection. For adults with complicated intra-abdominal infection, if a severity of illness score is used, the panel suggests APACHE II (Acute Physiology Age Chronic Health Evaluation II) as the preferred severity of illness score for risk stratification within 24 hours of hospitalization or ICU admission *(conditional recommendation, low certainty of evidence).*

Remarks:

- Because the WSES (World Society of Emergency Surgery) Sepsis Severity Score is specific to complicated intra-abdominal infection and performs well, it is an acceptable alternative to APACHE II for adults with complicated intra-abdominal infection.
- No severity of illness scoring system specific to complicated intra-abdominal infection can be recommended to guide management of pediatric patients with complicated intra-abdominal infection at present.

INTRODUCTION

This paper is part of a clinical practice guideline update on the risk assessment, diagnostic imaging, and microbiological evaluation of complicated intra-abdominal infections in adults, children, and pregnant people, developed by the Infectious Diseases Society of America [1-7]. Here, the guideline panel provides a recommendation for risk stratification in adults with complicated intra-abdominal infection, according to severity of illness as determined by a scoring system. This recommendation replaces previous statements in the last iteration of this guideline [8].

A complicated intra-abdominal infection extends beyond the hollow viscus of origin into the peritoneal space and is associated with either abscess formation or peritonitis; this term is not meant to describe the infection's severity or anatomy. An uncomplicated intra-abdominal infection involves intramural inflammation of the gastrointestinal tract and has a substantial probability of progressing to complicated infection if not adequately treated.

This recommendation is intended for use by healthcare professionals who care for patients with suspected intra-abdominal infections.

METHODS

The panel's recommendation is based upon evidence derived from systematic literature reviews and adheres to a standardized methodology for rating the certainty of evidence and strength of recommendation according to the GRADE (Grading of Recommendations Assessment, Development, and Evaluation) approach (Supplementary Figure 1) [9]. The recommendation has been endorsed by the European Society of Clinical Microbiology and Infectious Diseases (ESCMID) and the Pediatric Infectious Diseases Society (PIDS). Strong recommendations are made when the recommended course of action would apply to most people with few exceptions.

Conditional recommendations are made when the suggested course of action would apply to the majority of people with many exceptions and shared decision-making is important.

A comprehensive literature search (through October 2022) was conducted as part of a systematic review. Key eligibility criteria at both the topic and clinical question levels guided the search and selection of studies. For the clinical question addressed here, the panel considered patients with complicated intra-abdominal infection who received a scoring tool to assess risk. Studies reporting on 30-day or in-hospital mortality that referenced adjusted, multivariate analyses were included. Refer to the full list of eligibility criteria in the Supplementary Material.

Odds ratios, hazard ratios, and/or risk ratios or area under the receiver operating characteristic (ROC) curve and 95% CIs were generated for each scoring tool using random effects meta-analysis of pooled results [10]. Included studies underwent critical appraisal according to the GRADE approach, and then an assessment of benefits and harms of care options informed the recommendation [9, 11]. Details of the systematic review and guideline development processes are available in the Supplementary Material.

SUMMARY OF EVIDENCE

Severity of illness assessment can be helpful in risk stratification and for choosing treatment strategies for patients with complicated intra-abdominal infection. Although several severity of illness scoring tools have been studied in patients with complicated intra-abdominal infection, none had been subjected to a rigorous systematic review and meta-analysis.

Severity of Illness Scoring Systems for Complicated Intra-abdominal Infection. Over 20 different severity of illness scoring systems have been reported in the studies found. The four most common scoring systems were all disease-nonspecific and included: APACHE II [12],

SOFA (Sequential Organ Failure Assessment) [13], SAPS II (Simplified Acute Physiology Score II) [14], and ASA (American Society of Anesthesiologists) [15]. APACHE II was introduced in 1985 to reflect both premorbid factors such as patient age and chronic medical conditions, as well as acute changes in 12 physiologic parameters [12]. SOFA was introduced in 1996 to assess patients with sepsis-associated multiple organ failure or dysfunction in critical care units [13]. The score is based on six different organ systems (respiratory, cardiovascular, hepatic, coagulation, renal and neurological), but does not include age and chronic health or co-morbidities. SAPS II was introduced in 1993 based on logistic regression modeling of a North American/European multicenter study of adult ICU patients [14]. Scoring was based on 12 physiologic variables, age, type of hospital admission, and three variables related to underlying disease. ASA was originally developed in 1941 to assess anesthetic risks but was later found to be also useful for assessing surgical risks [15]. These four scoring systems were selected for systematic review and meta-analyses (Supplementary Table 1). Only five of the severity scoring systems were disease-specific and validated for patients with different complicated intra-abdominal infections (i.e., Peptic Ulcer Perforation score (PULP) [16, 17]; WSES Sepsis Severity score for patients with complicated intra-abdominal infection [18]; and Ranson [19], Glasgow, and BISAP (Bedside Index of Severity in Acute Pancreatitis) [20] for acute necrotizing pancreatitis. The WSES Sepsis Severity score was derived in Europe from six clinical determinants found to be independent predictors of hospital mortality among patients with complicated intra-abdominal infection (clinical condition of the patient on admission with either severe sepsis or shock, healthcare-associated infection, gastrointestinal origin of infection, delayed initial intervention greater than 24 hours, age greater than 70 years, and presence of immunosuppression) [18]. This scoring tool was also included for further analysis because it was

specifically developed for mortality prediction in all patients with complicated intra-abdominal infection (Supplementary Table 1). All other scoring systems were developed primarily for patients managed in ICUs not necessarily with complicated intra-abdominal infection.

Mortality Risk by Different Severity Scoring Systems. The performance of each severity of illness scoring system was compared by their odds ratio (OR), hazard ratio (HR), risk ratio (RR) or ROC (AUC) for mortality prediction. APACHE II was the most common independent prognostic factor for 30-day mortality identified by multivariate analyses (10 of 13 studies; [21-33]), followed by SOFA (9 of 11 studies; [33-43]), SAPS II (5 of 5 studies; [35, 42, 44-46]), ASA (4 of 7 studies; [16, 25, 32, 36, 47-49]. For each scoring system, forest plots of the odds or other risk ratios and AUCs are shown in Supplementary Figures 2-6.

The ability of each severity scoring system to discriminate between patients who died or did not from complicated intra-abdominal infection was quantitated by the concordance I-statistic, also known as ROC or area under the receiver operating characteristic (AUC) curve [50]. The ROC ranges from 0.5 (no discriminative ability) to 1 (perfect discriminative ability). Values from 0.7-0.8 are considered acceptable, 0.8-0.9 as excellent, and less than 0.6 as poor. The available pooled ROC of these scoring systems is shown in Supplementary Figures 2-6. All four disease-non-specific scoring systems performed well since their pooled AUC values were close to 0.8. APACHE II and SOFA had the best discriminative power (pooled AUC of 0.81 and 0.75, respectively) [23, 27, 32, 42, 51-54]. ROC data was reported by only one study each for SAPS II (AUC 0.83), ASA (0.70), and WSES Sepsis Severity Score (0.83) [42, 55, 56].

The evidence underpinning this recommendation is of low certainty due to study risk of bias concerns (according to QUIPS assessment; Supplementary Tables 2a-e) [57, 58]; inconsistency of results for the APACHE II studies, specifically; imprecision; and suspected

publication bias due to reporting statistically significant risk factors only (Supplementary Table 3).

Other Independent Risk Factors for Mortality. A total of 36 other independent risk factors besides severity of illness scores were identified from 34 studies (Supplementary Table 4) [16-18, 21, 22, 24, 26, 28, 31, 34, 35, 39, 42, 44-47, 54, 59-73]. Where more than one study identified the same risk factor, the pooled OR and 95% CI was reported and only if statistically significant. These risk factors were categorized into a) non-modifiable (16 factors), and b) potentially modifiable (20 factors). Among the latter, presence of renal (10 studies), cardiovascular (five studies) or respiratory (four studies) dysfunction, sepsis (3 studies) or shock (five studies), inadequate source control (three studies), delayed (>24 hours) source control (five studies), and inappropriate antimicrobial therapy (five studies) were the statistically significant independent mortality risk factors in adult patients with complicated intra-abdominal infection.

RATIONALE FOR RECOMMENDATION

APACHE II was chosen over other severity of illness scoring systems for risk assessment of patients with complicated intra-abdominal infection because: a) even though this tool is disease-non-specific, it has been rigorously tested in patients with complicated intra-abdominal infection and variable severity of illness; b) it appears to be valid independent of the source or site of infection; c) it has acceptable discriminative power as determined by ROC assessment; d) in a retrospective study of 544 patients with complicated intra-abdominal infection, after multivariate analysis of 37 variables, it was found to be one of six independent predictors for mortality, whereas SOFA was not [33]; e) it is relatively easy to calculate for all patients within 24 hours of

hospital admission, and a user-friendly calculator is available online (http://www.globalrph.com/apacheii.htm).

SOFA was not selected for three reasons: a) SOFA was developed originally to sequentially assess the degree of multiple organ failure in critically ill patients with sepsis, but is not suitable for categorizing patients with low-moderate severity without sepsis or organ failure within 24 hours of hospital admission; b) SOFA was not intended to indicate the success or failure of interventions or to influence medical management [13]; c) SOFA assesses the dysfunction of six organ systems (respiratory, cardiovascular, neurologic, renal, hepatic, coagulation) but does not take into consideration age and chronic health or comorbidities, which are important components of APACHE II. Although SAPS II performed well, it was evaluated in 5 studies with more limited study populations. Additionally, only one study reported ROC data for discriminative power. Similarly, ASA was evaluated in seven studies and was found to be an independent predictor for mortality in only four. ASA is also less precise and subject to inter-observer bias compared to other severity scoring systems [74]. WSES Sepsis Severity Score, the only disease-specific scoring tool for complicated intra-abdominal infection, also performed well; however, only moderately ill patients were included in these studies. This scoring system was developed and validated based on findings of a large multicenter study of patients with complicated intra-abdominal infection spanning 54 countries worldwide [18], and then validated in two single-center prospective studies from the United Arab Emirates (multivariate model) [75] and Kenya (univariate model) [76]. Importantly, the overall mortality in these studies was relatively low, ranging from 1% to 12.8% (mean 9.1%), and the most common complicated intra-abdominal infections included in these studies were perforated appendicitis or duodenal

perforation. It is unclear if the WSES sepsis severity score is generalizable to more seriously ill patients.

At present, no specific risk stratification scheme can be recommended to guide management of pediatric patients with complicated intra-abdominal infection. Although some scoring systems, including PRISM (Pediatric Risk of Mortality) [77], PIM (Pediatric Index of Mortality) [78], and PELOD-2 (Pediatric Logistic Organ Dysfunction-2) [79] have been validated for children admitted to pediatric intensive care units (PICUs), they are primarily used as tools for quality assessment and performance measures of PICUs. Their utility as a tool to guide individual patient management in disease-specific conditions such as complicated intra-abdominal infection both inside and outside of the PICU setting remains unclear.

IMPLEMENTATION CONSIDERATIONS

Risk stratification based on severity of illness is an important predictor of mortality in patients with complicated intra-abdominal infection and can guide appropriate therapy and urgency of source control. It is best to determine risk as early as possible, preferably within 24 hours of hospital admission. Risk groups based on APACHE II scores can be categorized into “low” (0-10), “intermediate” (11-15), and “high” (>15), with predicted mortality of 20-30% in the “intermediate” risk group and ~50% in the “high” risk group in patients with complicated intra-abdominal infection [50]. It is equally important to identify other independent risk factors for mortality not captured by APACHE II in “low” risk patients.

RESEARCH NEEDS

Just prior to publication, a new pediatric sepsis score was published, the Phoenix Sepsis Score [80] [81]. The score has been validated in pediatric emergency department, inpatient, and ICU settings. Future studies applying the Phoenix Sepsis Score, PRISM, PIM, and PELOD-2 to intra-abdominal infection specifically would be very helpful. Additionally, further validation of the WSES Sepsis Severity Score in more critically ill patients would be beneficial.

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Additional information: More detailed information on the analysis and development of recommendations is available in the Supplementary Material.

REFERENCES

1. Bonomo RA, Chow AW, Edwards MS, et al. 2024 Clinical practice guideline update by the Infectious Diseases Society of America on complicated intra-abdominal infections: risk assessment, diagnostic imaging, and microbiological evaluation in adults, children, and pregnant people. CID **2024**;
2. Bonomo RA, Tamma PD, Abrahamian FM, et al. 2024 Clinical practice guideline update by the Infectious Diseases Society of America on complicated intra-abdominal infections: diagnostic imaging of suspected acute appendicitis in adults, children, and pregnant people. CID **2024**;
3. Bonomo RA, Edwards MS, Abrahamian FM, et al. 2024 Clinical practice guideline update by the Infectious Diseases Society of America on complicated intra-abdominal infections: diagnostic imaging of suspected acute cholecystitis and acute cholangitis in adults, children, and pregnant people. CID **2024**;
4. Bonomo RA, Tamma PD, Abrahamian FM, et al. 2024 Clinical practice guideline update by the Infectious Diseases Society of America on complicated intra-abdominal infections: diagnostic imaging of Suspected acute diverticulitis in adults and pregnant people. CID **2024**;
5. Bonomo RA, Tamma PD, Abrahamian FM, et al. 2024 Clinical practice guideline update by the Infectious Diseases Society of America on complicated intra-abdominal infections: diagnostic imaging of suspected acute intra-abdominal abscess in adults, children, and pregnant people. CID **2024**;
6. Bonomo RA, Humphries R, Abrahamian FM, et al. 2024 Clinical practice guideline update by the Infectious Diseases Society of America on complicated intra-abdominal infections: utility of blood cultures in adults, children, and pregnant people. CID **2024**;
7. Bonomo RA, Humphries R, Abrahamian FM, et al. 2024 Clinical practice guideline update by the Infectious Diseases Society of America on complicated intra-abdominal infections: utility of intra-abdominal fluid cultures in adults, children, and pregnant people. CID **2024**;
8. Solomkin JS, Mazuski JE, Bradley JS, et al. Diagnosis and management of complicated intra-abdominal infection in adults and children: guidelines by the Surgical Infection

Society and the Infectious Diseases Society of America. Surg Infect (Larchmt) **2010**; 11(1): 79-109.

9. Guyatt GH, Oxman AD, Vist GE, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ **2008**; 336(7650): 924-926.

10. Review Manager 5 (RevMan 5). 5.4 ed. Copenhagen: The Cochrane Collaboration, 2020.

11. Infectious Diseases Society of America. IDSA Handbook on Clinical Practice Guideline Development. Available at: https://www.idsociety.org/practice-guideline/clinical-practice-guidelines-development-training-and-resources/. Accessed May 1, 2021.

12. Knaus WA, Draper EA, Wagner DP, Zimmerman JE. APACHE II: a severity of disease classification system. Crit Care Med **1985**; 13(10): 818-829.

13. Vincent JL, Moreno R, Takala J, et al. The SOFA (Sepsis-related Organ Failure Assessment) score to describe organ dysfunction/failure. On behalf of the Working Group on Sepsis-Related Problems of the European Society of Intensive Care Medicine. Intensive Care Med **1996**; 22(7): 707-710.

14. Le Gall JR, Lemeshow S, Saulnier F. A new Simplified Acute Physiology Score (SAPS II) based on a European/North American multicenter study. JAMA **1993**; 270(24): 2957-2963.

15. Knuf KM, Maani CV, Cummings AK. Clinical agreement in the American Society of Anesthesiologists physical status classification. Perioper Med (Lond) **2018**; 7: 14.

16. Møller MH, Engebjerg MC, Adamsen S, Bendix J, Thomsen RW. The Peptic Ulcer Perforation (PULP) score: a predictor of mortality following peptic ulcer perforation. A cohort study. Acta Anaesthesiol Scand **2012**; 56(5): 655-662.

17. Patel S, Kalra D, Kacheriwala S, Shah M, Duttaroy D. Validation of prognostic scoring systems for predicting 30-day mortality in perforated peptic ulcer disease. Turk J Surg **2019**; 35(4): 252-258.

18. Sartelli M, Abu-Zidan FM, Catena F, et al. Global validation of the WSES Sepsis Severity Score for patients with complicated intra-abdominal infections: a prospective multicentre study (WISS Study). World J Emerg Surg **2015**; 10: 61.

19. Ranson JH, Pasternack BS. Statistical methods for quantifying the severity of clinical acute pancreatitis. J Surg Res **1977**; 22(2): 79-91.

20. Li Y, Zhang J, Zou J. Evaluation of four scoring systems in prognostication of acute pancreatitis for elderly patients. BMC Gastroenterol **2020**; 20(1): 165.
21. Karvellas CJ, Dong V, Abraldes JG, Lester EL, Kumar A. The impact of delayed source control and antimicrobial therapy in 196 patients with cholecystitis-associated septic shock: a cohort analysis. Can J Surg **2019**; 62(3): 189-198.
22. Lichtenstern C, Herold C, Mieth M, et al. Relevance of Candida and other mycoses for morbidity and mortality in severe sepsis and septic shock due to peritonitis. Mycoses **2015**; 58(7): 399-407.
23. Pan J, Zhu Q, Zhang X, et al. Factors influencing the prognosis of patients with intra-abdominal infection and its value in assessing prognosis. Infect Drug Resist **2021**; 14: 3425-3432.
24. Politano AD, Hranjec T, Rosenberger LH, Sawyer RG, Tache Leon CA. Differences in morbidity and mortality with percutaneous versus open surgical drainage of postoperative intra-abdominal infections: a review of 686 cases. Am Surg **2011**; 77(7): 862-867.
25. Tartaglia D, Marin JN, Nicoli AM, et al. Predictive factors of mortality in open abdomen for abdominal sepsis: a retrospective cohort study on 113 patients. Updates Surg **2021**; 73(5): 1975-1982.
26. Tellor B, Skrupky LP, Symons W, High E, Micek ST, Mazuski JE. Inadequate source control and inappropriate antibiotics are key determinants of mortality in patients with intra-abdominal sepsis and associated bacteremia. Surg Infect (Larchmt) **2015**; 16(6): 785-793.
27. Özdoğan HK, Karateke F, Özyazıcı S, et al. The predictive value of red cell distribution width levels on mortality in intensive care patients with community-acquired intra-abdominal sepsis. Ulus Travma Acil Cerrahi Derg **2015**; 21(5): 352-357.
28. Guilbart M, Zogheib E, Ntouba A, et al. Compliance with an empirical antimicrobial protocol improves the outcome of complicated intra-abdominal infections: a prospective observational study. Br J Anaesth **2016**; 117(1): 66-72.
29. Wu Y, Ren J, Wang G, et al. Serum sodium: A reliable and validated predictor for mortality in enteric fistula patients complicated with sepsis. J Invest Surg **2015**; 28(3): 131-139.

30. Morais M, Gonçalves D, Bessa-Melo R, Devesa V, Costa-Maia J. The open abdomen: analysis of risk factors for mortality and delayed fascial closure in 101 patients. Porto Biomed J **2018**; 3(2): e14.
31. Li WS, Lee CH, Liu JW. Antifungal therapy did not improve outcomes including 30-day all-cause mortality in patients suffering community-acquired perforated peptic ulcer-associated peritonitis with Candida species isolated from their peritoneal fluid. J Microbiol Immunol Infect **2017**; 50(3): 370-376.
32. Buck DL, Vester-Andersen M, Møller MH. Accuracy of clinical prediction rules in peptic ulcer perforation: an observational study. Scand J Gastroenterol **2012**; 47(1): 28-35.
33. Huang S, Chen L, Liu J, et al. Novel multiparametric nomogram for overall survival prediction in complicated intra-abdominal infection: a multicenter study in China. Front Med (Lausanne) **2021**; 8: 627416.
34. Augustin P, Tanaka S, Tran-Dinh A, et al. Outcome and adequacy of empirical antibiotherapy in post-operative peritonitis: a retrospective study. Surg Infect (Larchmt) **2020**; 21(3): 284-292.
35. Dupont H, Friggeri A, Touzeau J, et al. Enterococci increase the morbidity and mortality associated with severe intra-abdominal infections in elderly patients hospitalized in the intensive care unit. J Antimicrob Chemother **2011**; 66(10): 2379-2385.
36. Pupelis G, Drozdova N, Mukans M, Malbrain ML. Serum procalcitonin is a sensitive marker for septic shock and mortality in secondary peritonitis. Anaesthesiol Intensive Ther **2014**; 46(4): 262-273.
37. Sim J, Hong SS, Kwak JY, Jung YT. Prediction of culture-positive sepsis and selection of empiric antibiotics in critically ill patients with complicated intra-abdominal infections: a retrospective study. Eur J Trauma Emerg Surg **2020**; 48(2): 963-971.
38. Luo X, Li L, Ou S, Zeng Z, Chen Z. Risk factors for mortality in abdominal infection patients in ICU: a retrospective study from 2011 to 2018. Front Med (Lausanne) **2022**; 9: 839284.
39. Montravers P, Augustin P, Grall N, et al. Characteristics and outcomes of anti-infective de-escalation during health care-associated intra-abdominal infections. Crit Care **2016**; 20: 83.

40. Wu Q, Ren J, Wang G, et al. The incidence, clinical outcomes, and risk factors of thrombocytopenia in intra-abdominal infection patients: a retrospective cohort study. PLoS One **2016**; 11(1): e0147482.
41. Roger C, Garrigue D, Bouhours G, et al. Time to source control and outcome in community-acquired intra-abdominal infections: the multicentre observational PERICOM study. Eur J Anaesthesiol **2022**; 39(6): 540-548.
42. Suarez-de-la-Rica A, Maseda E, Anillo V, et al. Biomarkers (procalcitonin, C reactive protein, and lactate) as predictors of mortality in surgical patients with complicated intra-abdominal infection. Surg Infect (Larchmt) **2015**; 16(3): 346-351.
43. Nugraha GL, Danardono E. A retrospective study of factors affecting mortality in patients with complicated intra-abdominal infection. Med J Malaysia **2022**; 77(5): 612-618.
44. De Waele J, Lipman J, Sakr Y, et al. Abdominal infections in the intensive care unit: characteristics, treatment and determinants of outcome. BMC Infect Dis **2014**; 14: 420.
45. Maseda E, Ramírez S, Picatto P, et al. Critically ill patients with community-onset intraabdominal infections: influence of healthcare exposure on resistance rates and mortality. PLoS One **2019**; 14(9): e0223092.
46. Alqarni A, Kantor E, Grall N, et al. Clinical characteristics and prognosis of bacteraemia during postoperative intra-abdominal infections. Crit Care **2018**; 22(1): 175.
47. Bensignor T, Lefevre JH, Creavin B, et al. Postoperative peritonitis after digestive tract surgery: surgical management and risk factors for morbidity and mortality, a cohort of 191 patients. World J Surg **2018**; 42(11): 3589-3598.
48. Faes S, Hübner M, Girardin T, Demartines N, Hahnloser D. Rate of stoma formation following damage-control surgery for severe intra-abdominal sepsis: a single-centre consecutive case series. BJS Open **2021**; 5(6).
49. Sim J, Hong SS, Kwak JY, Jung YT. Prediction of culture-positive sepsis and selection of empiric antibiotics in critically ill patients with complicated intra-abdominal infections: a retrospective study. Eur J Trauma Emerg Surg **2022**; 48(2): 963-971.
50. ClinCalc. APACHE II Calculator: Acute Physiology and Chronic Health Evaluation (APACHE) II score to predict hospital mortality. Available at: https://clincalc.com/IcuMortality/APACHEII.aspx. Accessed July 10, 2021.

51. Huang KL, Hsiao IT, Chang TY, et al. Neurodegeneration and vascular burden on cognition after midlife: a plasma and neuroimaging biomarker study. Front Hum Neurosci **2021**; 15: 735063.
52. Pawar RD, Shih JA, Balaji L, et al. Variation in SOFA (Sequential Organ Failure Assessment) score performance in different infectious states. J Intensive Care Med **2021**; 36(10): 1217-1222.
53. Pieroni M, Olier I, Ortega-Martorell S, Johnston BW, Welters ID. In-hospital mortality of sepsis differs depending on the origin of infection: an investigation of predisposing factors. Front Med (Lausanne) **2022**; 9: 915224.
54. Posadas-Calleja JG, Stelfox HT, Ferland A, et al. Derivation of a PIRO score for prediction of mortality in surgical patients with intra-abdominal sepsis. Am J Crit Care **2018**; 27(4): 287-294.
55. Dimitrov E, Minkov G, Enchev E, Yovtchev Y. The World Society of Emergency Surgery Sepsis Severity Score shows no prognostic superiority over the Mannheim Peritonitis Index in patients with complicated intra-abdominal infections. Journal of Emergency Medicine, Traume & Acute Care **2022**; 2022(4): 24.
56. Konishi T, Goto T, Fujiogi M, et al. New machine learning scoring system for predicting postoperative mortality in gastroduodenal ulcer perforation: a study using a Japanese nationwide inpatient database. Surgery **2022**; 171(4): 1036-1042.
57. Hayden JA, van der Windt DA, Cartwright JL, Côté P, Bombardier C. Assessing bias in studies of prognostic factors. Ann Intern Med **2013**; 158(4): 280-286.
58. McGuinness LA, Higgins JPT. Risk-of-bias VISualization (robvis): An R package and Shiny web app for visualizing risk-of-bias assessments. Res Synth Methods **2021**; 12(1): 55-61.
59. Claridge JA, Banerjee A, Kelly KB, et al. Bacterial species-specific hospital mortality rate for intra-abdominal infections. Surg Infect (Larchmt) **2014**; 15(3): 194-199.
60. Sartelli M, Abu-Zidan FM, Labricciosa FM, et al. Physiological parameters for Prognosis in Abdominal Sepsis (PIPAS) Study: a WSES observational study. World J Emerg Surg **2019**; 14: 34.
61. Kang CI, Chung DR, Ko KS, Peck KR, Song JH, (KONSID) KNftSoID. Risk factors for mortality and impact of broad-spectrum cephalosporin resistance on outcome in

bacteraemic intra-abdominal infections caused by Gram-negative bacilli. Scand J Infect Dis **2011**; 43(3): 202-208.

62. Gross DJ, Chung PJ, Smith MC, Roudnitsky V, Alfonso AE, Sugiyama G. End stage renal disease is associated with increased mortality in perforated gastroduodenal ulcers. Am Surg **2018**; 84(9): 1466-1469.

63. Sartelli M, Catena F, Ansaloni L, et al. Complicated intra-abdominal infections worldwide: the definitive data of the CIAOW Study. World J Emerg Surg **2014**; 9: 37.

64. Zhang J, Zhao C, Chen H, et al. A multicenter epidemiology study on the risk factors and clinical outcomes of nosocomial intra-abdominal infections in China: results from the Chinese Antimicrobial Resistance Surveillance of Nosocomial Infections (CARES) 2007-2016. Infect Drug Resist **2018**; 11: 2311-2319.

65. Blot S, Antonelli M, Arvaniti K, et al. Epidemiology of intra-abdominal infection and sepsis in critically ill patients: "AbSeS", a multinational observational cohort study and ESICM Trials Group Project. Intensive Care Med **2019**; 45(12): 1703-1717.

66. Schneider J, Hapfelmeier A, Thöres S, et al. Mortality risk for Acute Cholangitis (MAC): a risk prediction model for in-hospital mortality in patients with acute cholangitis. BMC Gastroenterol **2016**; 16: 15.

67. Yıldız BD, Özden S, Saylam B, Martlı F, Tez M. Simplified scoring system for prediction of mortality in acute suppurative cholangitis. Kaohsiung J Med Sci **2018**; 34(7): 415-419.

68. Ji Y, Cheng B, Xu Z, et al. Impact of sarcopenic obesity on 30-day mortality in critically ill patients with intra-abdominal sepsis. J Crit Care **2018**; 46: 50-54.

69. Xu Z, Cheng B, Fu S, et al. Coagulative biomarkers on admission to the ICU predict acute kidney injury and mortality in patients with septic shock caused by intra-abdominal infection. Infect Drug Resist **2019**; 12: 2755-2764.

70. Abaziou T, Vardon-Bounes F, Conil JM, et al. Outcome of community- versus hospital-acquired intra-abdominal infections in intensive care unit: a retrospective study. BMC Anesthesiol **2020**; 20(1): 295.

71. Tsuchiya A, Yasunaga H, Tsutsumi Y, Kawahara T, Matsui H, Fushimi K. Nationwide observational study of mortality from complicated intra-abdominal infections and the role of bacterial cultures. Br J Surg **2019**; 106(5): 606-615.

72. De Pascale G, Carelli S, Vallecoccia MS, et al. Risk factors for mortality and cost implications of complicated intra-abdominal infections in critically ill patients. J Crit Care **2019**; 50: 169-176.
73. Sallinen V, Mali J, Leppaniemi A, Mentula P. Assessment of risk for recurrent diverticulitis: a proposal of risk score for complicated recurrence. Medicine (Baltimore) **2015**; 94(8): e557.
74. Blamey SL, Imrie CW, O'Neill J, Gilmour WH, Carter DC. Prognostic factors in acute pancreatitis. Gut **1984**; 25(12): 1340-6.
75. Abdel-Kader S, Sartelli M, Abu-Zidan FM. Complicated intra-abdominal infections: a prospective validation study of the WSES Sepsis Severity Score. Singapore Med J **2019**; 60(6): 317-321.
76. Mwenda K, Daniel O, Mark A. Utility of World Society of Emergency Surgery Sepsis Severity Score in predicting outcomes of intra-abdominal infections. Ann Afr Surg **2020**; 17: 65-68.
77. Costa GA, Delgado AF, Ferraro A, Okay TS. Application of the pediatric risk of mortality (PRISM) score and determination of mortality risk factors in a tertiary pediatric intensive care unit. Clinics (Sao Paulo) **2010**; 65(11): 1087-1092.
78. Shann F, Pearson G, Slater A, Wilkinson K. Paediatric Index of Mortality (PIM): a mortality prediction model for children in intensive care. Intensive Care Med **1997**; 23(2): 201-207.
79. Leteurtre S, Duhamel A, Salleron J, et al. PELOD-2: an update of the PEdiatric Logistic Organ Dysfunction score. Crit Care Med **2013**; 41(7): 1761-1773.
80. Sanchez-Pinto LN, Bennett TD, DeWitt PE, et al. Development and validation of the Phoenix Criteria for pediatric sepsis and septic shock. JAMA **2024**; 331(8): 675-686.
81. Schlapbach LJ, Watson RS, Sorce LR, et al. International consensus criteria for pediatric sepsis and septic shock. JAMA **2024**; 331(8): 665-674.