

FACTORES DE RIESGO DE NEUMONIA ASOCIADA AL VENTILADOR EN PACIENTES ADULTOS CRITICAMENTE ENFERMOS EN UNA UNIDAD DE CUIDADOS INTENSIVOS DURANTE EL AÑO 2023

Alex David Yguaran Velázquez

Código estudiantil:

2022214427539

María Rosa Baquero Pérez

Código estudiantil:

2022214427540

Trabajo de Investigación presentado como requisito para optar el título de:
Especialista en Medicina Crítica y Cuidados Intensivos

Tutor(es):

Mauricio Aldana Roa

MD | Spc. Cirujano General | Intensivista

RESUMEN

Introducción: Los pacientes críticamente enfermos en ventilación mecánica invasiva tienen el riesgo de sufrir de neumonía asociada al ventilador. Investigamos los factores de riesgo para el desarrollo de neumonía asociada al ventilador.

Objetivos: Determinar los factores de riesgo de neumonía asociada al ventilador en pacientes adultos críticamente enfermos en una unidad de cuidados intensivos en Barranquilla (Colombia) desde el 1 de enero del 2023 al 31 de diciembre del 2023.

Materiales y métodos: Un estudio retrospectivo de pacientes críticamente enfermos admitidos a la unidad de cuidados intensivos en Barranquilla durante el año 2023. Se evaluaron diversos factores de riesgo para neumonía asociada al ventilador mediante un modelo de regresión logística binaria, calculando las odds ratio con sus intervalos de confianza al 95%.

Resultados: Se incluyeron 100 pacientes durante el periodo de estudio; de ellos 23 pacientes presentaron neumonía asociada al ventilador, principalmente por microorganismos gramnegativos como la *Klebsiella pneumoniae* y *Pseudomona aeruginosa*. Los modelos de regresión logística encontraron que la presencia de la duración de la ventilación mecánica invasiva y una ventilación mecánica invasiva ≥ 10 días fueron factores de riesgo para la variable de estudio.

Conclusiones: Entre los pacientes críticamente enfermos la duración de la ventilación mecánica invasiva y una ventilación mecánica invasiva ≥ 10 días se asociaron con la presencia de neumonía asociada al ventilador.

Palabras clave: Unidad de cuidados intensivos; Ventilación mecánica; Neumonía asociada al ventilador; Factores de riesgo; Adultos.

ABSTRACT

Introduction: Critically ill patients on invasive mechanical ventilation are at risk of ventilator-associated pneumonia. We investigated risk factors for the development of ventilator-associated pneumonia.

Objectives: To determine the risk factors for ventilator-associated pneumonia in critically ill adult patients in an intensive care unit in Barranquilla (Colombia) from January 1, 2023 to December 31, 2023.

Materials and Methods: A retrospective study of critically ill patients admitted to the intensive care unit in Barranquilla during 2023. Various risk factors for ventilator-associated pneumonia were evaluated using a binary logistic regression model, calculating the odds ratios with confidence intervals of 95%.

Results: 100 patients were included during the study period; Of them, 23 patients presented ventilator-associated pneumonia, mainly due to gram-negative microorganisms such as *Klebsiella pneumoniae* and *Pseudomona aeruginosa*. Logistic regression models found that the presence of duration of invasive mechanical ventilation, and invasive mechanical ventilation ≥ 10 days were risk factors for the study variable.

Conclusions: Among critically ill patients, duration of invasive mechanical ventilation, and invasive mechanical ventilation ≥ 10 days were associated with the presence of ventilator-associated pneumonia.

Key Words: Intensive care unit; Mechanic ventilation; Ventilator-associated pneumonia; Risk factor's; Adults.

REFERENCIAS BIBLIOGRÁFICAS

1. Dereli N, Ozayar E, Degerli S, Sahin S, Koç F. Three-Year Evaluation of Nosocomial Infection Rates of the ICU. *Brazilian J Anesthesiol* [Internet]. 2013 Jan;63(1):73–84. Available from: [https://doi.org/10.1016/S0034-7094\(13\)70199-5](https://doi.org/10.1016/S0034-7094(13)70199-5)
2. Mitharwal SM, Yaddanapudi S, Bhardwaj N, Gautam V, Biswal M, Yaddanapudi L. Intensive care unit-acquired infections in a tertiary care hospital: An epidemiologic survey and influence on patient outcomes. *Am J Infect Control* [Internet]. 2016 Jul;44(7):e113–7. Available from: <https://doi.org/10.1016/j.ajic.2016.01.021>
3. Kalanuria AA, Zai W, Mirski M. Ventilator-associated pneumonia in the ICU. *Crit Care* [Internet]. 2014 Mar 18;18(2):208. Available from: <https://doi.org/10.1186/cc13775>
4. Papazian L, Klompas M, Luyt C-E. Ventilator-associated pneumonia in adults: a narrative review. *Intensive Care Med* [Internet]. 2020 May 10;46(5):888–906. Available from: <https://doi.org/10.1007/s00134-020-05980-0>
5. Chien J-Y, Hsueh P-R, Yu C-J, Yang P-C. The evolution of drug-resistant microorganisms in patients with prolonged mechanical ventilation. *Am J Infect Control* [Internet]. 2009 Apr;37(3):231–6. Available from: <https://doi.org/10.1016/j.ajic.2008.05.016>
6. Chang Y, Jeon K, Lee S-M, Cho Y-J, Kim YS, Chong YP, et al. The Distribution

- of Multidrug-resistant Microorganisms and Treatment Status of Hospital-acquired Pneumonia/Ventilator-associated Pneumonia in Adult Intensive Care Units: a Prospective Cohort Observational Study. *J Korean Med Sci* [Internet]. 2021;36(41). Available from: <https://doi.org/10.3346/jkms.2021.36.e251>
7. Pugin J, Auckenthaler R, Mili N, Janssens J-P, Lew PD, Suter PM. Diagnosis of Ventilator-associated Pneumonia by Bacteriologic Analysis of Bronchoscopic and Nonbronchoscopic “Blind” Bronchoalveolar Lavage Fluid. *Am Rev Respir Dis* [Internet]. 1991 May;143(5_pt_1):1121–9. Available from: https://doi.org/10.1164/ajrccm/143.5_Pt_1.1121
 8. Lewis SC, Li L, Murphy M V., Klompas M. Risk Factors for Ventilator-Associated Events. *Crit Care Med* [Internet]. 2014 Aug;42(8):1839–48. Available from: <https://doi.org/10.1097/CCM.0000000000000338>
 9. Xu Y, Lai C, Xu G, Meng W, Zhang J, Hou H, et al. Risk factors of ventilator-associated pneumonia in elderly patients receiving mechanical ventilation. *Clin Interv Aging* [Internet]. 2019 Jun;Volume 14:1027–38. Available from: <https://doi.org/10.2147/CIA.S197146>
 10. Society AT. Guidelines for the Management of Adults with Hospital-acquired, Ventilator-associated, and Healthcare-associated Pneumonia. *Am J Respir Crit Care Med* [Internet]. 2005 Feb 15 [cited 2018 Aug 6];171(4):388–416. Available from: <https://doi.org/10.1164/rccm.200405-644ST>
 11. Ferrer M, Valencia M, Nicolas JM, Bernadich O, Badia JR, Torres A. Early Noninvasive Ventilation Averts Extubation Failure in Patients at Risk. *Am J Respir Crit Care Med* [Internet]. 2006 Jan 15;173(2):164–70. Available from:

<https://doi.org/10.1164/rccm.200505-718OC>

12. Rodrigues PM de A, Carmo Neto E do, Santos LR de C, Knibel MF. Pneumonia associada à ventilação mecânica: epidemiologia e impacto na evolução clínica de pacientes em uma unidade de terapia intensiva. *J Bras Pneumol* [Internet]. 2009 Nov;35(11):1084–91. Available from: <https://doi.org/10.1590/s1806-37132009001100005>
13. Varón F, Londoño D, Álvarez C, Taborda A, Prieto V. Costo-efectividad de linezolid comparado con vancomicina en el manejo de la neumonía asociada a ventilación mecánica en Colombia. *Infectio* [Internet]. No longer published by Elsevier; 2014 Oct 1 [cited 2018 Aug 6];18(4):143–52. Available from: <https://doi.org/10.1016/j.infect.2014.09.002>
14. Speck K, Rawat N, Weiner N, Tujuba H, Farley D, Berenholtz S. A systematic approach for developing a ventilator-associated pneumonia prevention bundle. *Am J Infect Control* [Internet]. Mosby; 2016 Jun 1 [cited 2018 Aug 6];44(6):652–6. Available from: <https://doi.org/10.1016/j.ajic.2015.12.020>
15. Díaz L, Llauradó M, Rello J, Restrepo M. Prevención no farmacológica de la neumonía asociada a ventilación mecánica. *Arch Bronconeumol* [Internet]. Elsevier Doyma; 2010 Apr 1 [cited 2018 Aug 5];46(4):188–95. Available from: <https://doi.org/10.1016/j.arbres.2009.08.001>
16. Ding C, Zhang Y, Yang Z, Wang J, Jin A, Wang W, et al. Incidence, temporal trend and factors associated with ventilator-associated pneumonia in mainland China: a systematic review and meta-analysis. *BMC Infect Dis* [Internet]. 2017 Dec 4;17(1):468. Available from: <https://doi.org/10.1186/s12879-017-2566-7>

17. Walter J, Haller S, Quinten C, Kärki T, Zacher B, Eckmanns T, et al. Healthcare-associated pneumonia in acute care hospitals in European Union/European Economic Area countries: an analysis of data from a point prevalence survey, 2011 to 2012. *Eurosurveillance* [Internet]. 2018 Aug 9;23(32). Available from: <https://doi.org/10.2807/1560-7917.ES.2018.23.32.1700843>
18. Rosenthal VD, Rodrigues C, Álvarez-Moreno C, Madani N, Mitrev Z, Ye G, et al. Effectiveness of a multidimensional approach for prevention of ventilator-associated pneumonia in adult intensive care units from 14 developing countries of four continents. *Crit Care Med* [Internet]. 2012 Dec;40(12):3121–8. Available from: <https://doi.org/10.1097/CCM.0b013e3182657916>
19. Martin-Loeches I, Rodriguez AH, Torres A. New guidelines for hospital-acquired pneumonia/ventilator-associated pneumonia: USA vs. Europe. *Curr Opin Crit Care* [Internet]. 2018 Oct;24(5):347–52. Available from: <https://doi.org/10.1097/mcc.0000000000000535>
20. Kalil AC, Metersky M., Klompas M, Muscedere J, Sweeney DA, Palmer LB, et al. Management of Adults With Hospital-acquired and Ventilator-associated Pneumonia: 2016 Clinical Practice Guidelines by the Infectious Diseases Society of America and the American Thoracic Society. *Clin Infect Dis* [Internet]. 2016 Sep 1;63(5):e61–111. Available from: <https://doi.org/10.1093/cid/ciw353>
21. Feng D-Y, Zhou Y-Q, Zhou M, Zou X-L, Wang Y-H, Zhang T-T. Risk Factors for Mortality Due to Ventilator-Associated Pneumonia in a Chinese Hospital: A

- Retrospective Study. *Med Sci Monit* [Internet]. 2019 Oct 12;25:7660–5. Available from: <https://doi.org/10.12659/MSM.916356>
22. Wu D, Wu C, Zhang S, Zhong Y. Risk Factors of Ventilator-Associated Pneumonia in Critically Ill Patients. *Front Pharmacol* [Internet]. 2019 May 9;10. Available from: <https://doi.org/10.3389/fphar.2019.00482>
23. Rosenthal V, Bijie H, Maki D., Mehta Y, Apisarnthanarak A, Medeiros EA, et al. International Nosocomial Infection Control Consortium (INICC) report, data summary of 36 countries, for 2004-2009. *Am J Infect Control* [Internet]. Mosby; 2012 Jun 1 [cited 2018 Aug 6];40(5):396–407. Available from: <https://doi.org/10.1016/j.ajic.2011.05.020>
24. Jaimes F, De La Rosa G, Gómez E, Múnera P, Ramírez J, Castrillón S. Incidence and risk factors for ventilator-associated pneumonia in a developing country: Where is the difference? *Respir Med* [Internet]. 2007 Apr;101(4):762–7. Available from: <https://doi.org/10.1016/j.rmed.2006.08.008>
25. Ortiz G, Dueñas C, Garay M. Neumonía asociada a la ventilación mecánica: prevención, diagnóstico y tratamiento. *Acta Colomb Cuid Intensivo* [Internet]. Elsevier; 2015 Oct 1 [cited 2018 Aug 5];15(4):312–21. Available from: <https://doi.org/10.1016/j.acci.2015.09.006>
26. Barrera-Robledo ME, Uribe-Caputi JC. Prevalencia y factores asociados a neumonía nosocomial en la unidad de cuidado intensivo. *MedUNAB* [Internet]. 2022 Sep 27;25(2):227–36. Available from: <https://doi.org/10.29375/01237047.4099>
27. Melsen WG, Rovers MM, Groenwold RH, Bergmans DC, Camus C, Bauer TT,

- et al. Attributable mortality of ventilator-associated pneumonia: a meta-analysis of individual patient data from randomised prevention studies. *Lancet Infect Dis* [Internet]. 2013 Aug;13(8):665–71. Available from: [https://doi.org/10.1016/S1473-3099\(13\)70081-1](https://doi.org/10.1016/S1473-3099(13)70081-1)
28. Ariel Núñez S, Roveda G, Soledad Zárate M, Emmerich M, Teresa Verón M. Ventilator-associated pneumonia in patients on prolonged mechanical ventilation: description, risk factors for mortality, and performance of the SOFA score. *J Bras Pneumol* [Internet]. 2021 Jun 1;e20200569. Available from: <https://doi.org/10.36416/1806-3756/e20200569>
29. Charles MP. Ventilator-associated pneumonia. *Australas Med J* [Internet]. 2014 Aug 31;334–44. Available from: <https://doi.org/10.4066/AMJ.2014.2105>
30. Torres A, Niederman MS, Chastre J, Ewig S, Fernandez-Vandellos P, Hanberger H, et al. International ERS/ESICM/ESCMID/ALAT guidelines for the management of hospital-acquired pneumonia and ventilator-associated pneumonia. *Eur Respir J* [Internet]. 2017 Sep 10;50(3):1700582. Available from: <https://doi.org/10.1183/13993003.00582-2017>
31. Enrique D, Rodriguez M. Boletín epidemiológico de las infecciones intrahospitalarias [Internet]. 2010 [cited 2018 Aug 6]. Available from: http://saludcapital.gov.co/sitios/VigilanciaSaludPublica/Todo_IIH/Boletín_IIH_2010.pdf.
32. Díaz E, Martín-Loeches I, Vallés J. Neumonía nosocomial. *Enferm Infecc Microbiol Clin* [Internet]. 2013 Dec;31(10):692–8. Available from: <https://doi.org/10.1016/j.eimc.2013.04.014>

33. Namias N, Samiian L, Nino D, Shirazi E, O???Neill K, Kett DH, et al. Incidence and Susceptibility of Pathogenic Bacteria Vary between Intensive Care Units within a Single Hospital: Implications for Empiric Antibiotic Strategies. *J Trauma Inj Infect Crit Care* [Internet]. 2000 Oct;49(4):638–46. Available from: <https://doi.org/10.1097/00005373-200010000-00010>
34. TROUILLET J-L, CHASTRE J, VUAGNAT A, JOLY-GUILLOU M-L, COMBAUX D, DOMBRET M-C, et al. Ventilator-associated Pneumonia Caused by Potentially Drug-resistant Bacteria. *Am J Respir Crit Care Med* [Internet]. 1998 Feb 1;157(2):531–9. Available from: <https://doi.org/10.1164/ajrccm.157.2.9705064>
35. Olaechea PM, Insausti J, Blanco A, Luque P. Epidemiología e impacto de las infecciones nosocomiales. *Med Intensiva* [Internet]. 2010 May;34(4):256–67. Available from: <https://doi.org/10.1016/j.medin.2009.11.013>
36. Lynch JP. Hospital-Acquired Pneumonia. *Chest* [Internet]. 2001 Feb;119(2):373S–384S. Available from: https://doi.org/10.1378/chest.119.2_suppl.373s
37. Tejada Artigas A, Bello Drona S, Chacón Vallés E, Muñoz Marco J, Villuendas Usón MC, Figueras P, et al. Risk factors for nosocomial pneumonia in critically ill trauma patients. *Crit Care Med* [Internet]. 2001 Feb;29(2):304–9. Available from: <https://doi.org/10.1097/00003246-200102000-00015>
38. Hanes SD, Demirkan K, Tolley E, Boucher BA, Croce MA, Wood GC, et al. Risk Factors for Late-Onset Nosocomial Pneumonia Caused by *Stenotrophomonas maltophilia* in Critically Ill Trauma Patients. *Clin Infect Dis*

- [Internet]. 2002 Aug;35(3):228–35. Available from:
<https://doi.org/10.1086/341022>
39. Bercault N, Boulain T. Mortality rate attributable to ventilator-associated nosocomial pneumonia in an adult intensive care unit: A prospective case-control study. *Crit Care Med* [Internet]. 2001 Dec;29(12):2303–9. Available from: <https://doi.org/10.1097/00003246-200112000-00012>
40. Celis R, Torres A, Gatell JM, Almela M, Rodríguez-Roisin R, Agustí-Vidal A. Nosocomial Pneumonia. *Chest* [Internet]. 1988 Feb;93(2):318–24. Available from: <https://doi.org/10.1378/chest.93.2.318>
41. Drakulovic MB, Torres A, Bauer TT, Nicolas JM, Nogué S, Ferrer M. Supine body position as a risk factor for nosocomial pneumonia in mechanically ventilated patients: a randomised trial. *Lancet* [Internet]. 1999 Nov;354(9193):1851–8. Available from: [https://doi.org/10.1016/S0140-6736\(98\)12251-1](https://doi.org/10.1016/S0140-6736(98)12251-1)
42. Carratala J, Gudiol F, Pallares R, Dorca J, Verdaguer R, Ariza J, et al. Risk factors for nosocomial *Legionella pneumophila* pneumonia. *Am J Respir Crit Care Med* [Internet]. 1994 Mar;149(3):625–9. Available from: <http://dx.doi.org/10.1164/ajrccm.149.3.8118629>
43. Rello J, Torres A, Ricart M, Valles J, Gonzalez J, Artigas A, et al. Ventilator-associated pneumonia by *Staphylococcus aureus*. Comparison of methicillin-resistant and methicillin-sensitive episodes. *Am J Respir Crit Care Med* [Internet]. 1994 Dec;150(6):1545–9. Available from: <http://dx.doi.org/10.1164/ajrccm.150.6.7952612>

44. Barreiro-López B, Maria Tricas J, Mauri E, Quintana S, Garau J. Factores de riesgo y pronósticos de la neumonía nosocomial en los pacientes no ingresados en unidades de cuidados intensivos. *Enferm Infecc Microbiol Clin* [Internet]. 2005 Sep;23(9):519–24. Available from: <http://dx.doi.org/10.1157/13080261>
45. Asensio Martín MJ, Hernández Bernal M, Yus Teruel S, Minvielle A. Infecciones en el paciente crítico. *Med - Programa Form Médica Contin Acreditado* [Internet]. 2018 Apr;12(52):3085–96. Available from: <http://dx.doi.org/10.1016/j.med.2018.03.014>
46. Croce MA, Swanson JM, Magnotti LJ, Claridge JA, Weinberg JA, Wood GC, et al. The Futility of the Clinical Pulmonary Infection Score in Trauma Patients. *J Trauma Inj Infect Crit Care* [Internet]. 2006 Mar;60(3):523–8. Available from: <http://dx.doi.org/10.1097/01.ta.0000204033.78125.1b>
47. Sirvent JM, Torres A, Vidaur L, Armengol J, de Batlle J, Bonet A. Tracheal colonisation within 24 h of intubation in patients with head trauma: risk factor for developing early-onset ventilator-associated pneumonia. *Intensive Care Med* [Internet]. 2000 Sep 18;26(9):1369–72. Available from: <http://dx.doi.org/10.1007/s001340000611>
48. Koenig SM, Truwit JD. Ventilator-Associated Pneumonia: Diagnosis, Treatment, and Prevention. *Clin Microbiol Rev* [Internet]. 2006 Oct;19(4):637–57. Available from: <http://dx.doi.org/10.1128/CMR.00051-05>
49. García-Vázquez E, Marcos MA, Mensa J, de Roux A, Puig J, Font C, et al. Assessment of the Usefulness of Sputum Culture for Diagnosis of Community-

- Acquired Pneumonia Using the PORT Predictive Scoring System. Arch Intern Med [Internet]. 2004 Sep 13;164(16):1807. Available from: <http://dx.doi.org/10.1001/archinte.164.16.1807>
50. Salas Segura DA. Neumonía nosocomial: definición, diagnóstico y tratamiento. Rev Médica la Univ Costa Rica [Internet]. 2011 Sep 21;5(2). Available from: <https://doi.org/10.15517/rmu.v5i2.7866>
51. Ibrahim EH, Ward S, Sherman G, Schaiff R, Fraser VJ, Kollef MH. Experience with a clinical guideline for the treatment of ventilator-associated pneumonia. Crit Care Med [Internet]. 2001 Jun;29(6):1109–15. Available from: <https://doi.org/10.1097/00003246-200106000-00003>
52. Rello J, Diaz E. Pneumonia in the intensive care unit. Crit Care Med [Internet]. 2003 Oct;31(10):2544–51. Available from: <https://doi.org/10.1097/01.CCM.0000089928.84326.D2>
53. Ulldemolins M, Restrepo M, Rello J. Medidas farmacológicas para la prevención de la neumonía asociada a la ventilación mecánica. Med Clin (Barc) [Internet]. Elsevier Doyma; 2011 Jan 15 [cited 2018 Aug 6];136(1):21–5. Available from: <https://doi.org/10.1016/j.medcli.2009.10.012>
54. Cook DJ. Incidence of and Risk Factors for Ventilator-Associated Pneumonia in Critically Ill Patients. Ann Intern Med [Internet]. 1998 Sep 15;129(6):433. Available from: <https://doi.org/10.7326/0003-4819-129-6-199809150-00002>
55. Halili A, Ghafari S, Saghaei M, Atashi V. Prevention of ventilator-associated pneumonia by a nose care program combining with oral care among patients hospitalized in intensive care units: a single-blind randomized controlled trial.

- Med Clínica Práctica [Internet]. 2024 Jan;7(1):100401. Available from: <https://doi.org/10.1016/j.mcpsp.2023.100401>
56. Mehta A, Bhagat R. Preventing Ventilator-Associated Infections. Clin Chest Med [Internet]. Elsevier; 2016 Dec 1 [cited 2018 Aug 6];37(4):683–92. Available from: <https://doi.org/10.1016/j.ccm.2016.07.008>
57. Mazwi S, Van Blydenstein SA, Mukansi M. Ventilator-associated pneumonia in an academic intensive care unit in Johannesburg, South Africa. African J Thorac Crit Care Med [Internet]. 2023 Nov 29;158–64. Available from: <https://doi.org/10.7196/AJTCCM.2023.v29i4.154>
58. Amaral ACKB, Holder MW. Timing of Antimicrobial Therapy after Identification of Ventilator-Associated Condition Is Not Associated with Mortality in Patients with Ventilator-Associated Pneumonia: A Cohort Study. Salluh JIF, editor. PLoS One [Internet]. 2014 May 19;9(5):e97575. Available from: <https://doi.org/10.1371/journal.pone.0097575>
59. Vo-Pham-Minh T, Duong-Thi-Thanh V, Nguyen T, Phan-Tran-Xuan Q, Phan-Thi H, Bui-Anh T, et al. The Impact of Risk Factors on Treatment Outcomes of Nosocomial Pneumonia Due to Gram-Negative Bacteria in the Intensive Care Unit. Pulm Ther [Internet]. 2021 Dec 15;7(2):563–74. Available from: <https://doi.org/10.1007/s41030-021-00175-4>
60. Otero-Antón E, González-Quintela A, López-Soto A, López-Ben S, J L, Pérez LF. Cecal Ligation and Puncture as a Model of Sepsis in the Rat: Influence of the Puncture Size on Mortality, Bacteremia, Endotoxemia and Tumor Necrosis Factor Alpha Levels. Karger [Internet]. 201AD;33(2). Available from:

<https://doi.org/10.1159/000049698>

61. Boomer JS, To K, Chang KC, Takasu O, Osborne DF, Walton AH, et al. Immunosuppression in Patients Who Die of Sepsis and Multiple Organ Failure. JAMA [Internet]. 2011 Dec 21;306(23):2594. Available from: <https://doi.org/10.1001/jama.2011.1829>
62. Philippart F, Bouroche G, Timsit J-F, Garrouste-Orgeas M, Azoulay E, Darmon M, et al. Decreased Risk of Ventilator-Associated Pneumonia in Sepsis Due to Intra-Abdominal Infection. Yende S, editor. PLoS One [Internet]. 2015 Sep 4;10(9):e0137262. Available from: <https://doi.org/10.1371/journal.pone.0137262>
63. Thompson DA, Makary MA, Dorman T, Pronovost PJ. Clinical and Economic Outcomes of Hospital Acquired Pneumonia in Intra-Abdominal Surgery Patients. Ann Surg [Internet]. 2006 Apr;243(4):547–52. Available from: <https://doi.org/10.1097/01.sla.0000207097.38963.3b>
64. van Vught LA, Klein Klouwenberg PMC, Spitoni C, Scicluna BP, Wiewel MA, Horn J, et al. Incidence, Risk Factors, and Attributable Mortality of Secondary Infections in the Intensive Care Unit After Admission for Sepsis. JAMA [Internet]. 2016 Apr 12;315(14):1469. Available from: <https://doi.org/10.1001/jama.2016.2691>
65. Spalding MC, Cripps MW, Minshall CT. Ventilator-Associated Pneumonia. Crit Care Clin [Internet]. 2017 Apr;33(2):277–92. Available from: <https://doi.org/10.1016/j.ccc.2016.12.009>
66. Abdelrazik A, Salah M. Ventilator-associated pneumonia in adult intensive

- care unit prevalence and complications. *Egypt J Crit Care Med* [Internet]. Elsevier; 2017 Aug 1 [cited 2018 Aug 6];5(2):61–3. Available from: <https://doi.org/10.1016/j.ejccm.2017.06.001>
67. Kózka M, Segá A, Wojnar-Gruszka K, Tarnawska A, Gniadek A. Risk Factors of Pneumonia Associated with Mechanical Ventilation. *Int J Environ Res Public Health* [Internet]. 2020 Jan 19;17(2):656. Available from: <https://doi.org/10.3390/ijerph17020656>
68. Wałaszek M, Kosiarska A, Gniadek A, Kołpa M, Wolak Z, Dobroś W, et al. The risk factors for hospital-acquired pneumonia in the Intensive Care Unit. *Przegl Epidemiol* [Internet]. 2016;70(1):15–20, 107–10. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/27344468>
69. Oliveira J, Zagalo C, Cavaco-Silva P. Prevention of ventilator-associated pneumonia. *Rev Port Pneumol* [Internet]. 2014 May;20(3):152–61. Available from: <https://doi.org/10.1016/j.rppneu.2014.01.002>
70. Prescott HC, O'Brien JM. Prevention of ventilator-associated pneumonia in adults. *F1000 Med Rep* [Internet]. 2010 Feb 24;2. Available from: <https://doi.org/10.3410/M2-15>
71. Harrell KN, Lee WB, Rooks HJ, Briscoe WE, Capote W, Dart BW, et al. Early pneumonia diagnosis decreases ventilator-associated pneumonia rates in trauma population. *J Trauma Acute Care Surg* [Internet]. 2023 Jan;94(1):30–5. Available from: <https://doi.org/10.1097/TA.0000000000003808>
72. Cook A, Norwood S, Berne J. Ventilator-Associated Pneumonia is More Common and of Less Consequence in Trauma Patients Compared With Other

- Critically Ill Patients. *J Trauma Inj Infect Crit Care* [Internet]. 2010 Nov;69(5):1083–91. Available from: <https://doi.org/10.1097/TA.0b013e3181f9fb51>
73. Raja M, Ely A, Zolfaghari P. Ventilator-associated pneumonia in a trauma ICU. *Crit Care* [Internet]. 2015 Mar 16;19(S1):P319. Available from: <https://doi.org/10.1186/cc14399>
74. Gianakis A, McNett M, Belle J, Moran C, Grimm D. Risk Factors for Ventilator-Associated Pneumonia. *J Trauma Nurs* [Internet]. 2015 May;22(3):125–31. Available from: <https://doi.org/10.1097/JTN.0000000000000121>
75. Li Y, Liu C, Xiao W, Song T, Wang S. Incidence, Risk Factors, and Outcomes of Ventilator-Associated Pneumonia in Traumatic Brain Injury: A Meta-analysis. *Neurocrit Care* [Internet]. 2020 Feb 12;32(1):272–85. Available from: <https://doi.org/10.1007/s12028-019-00773-w>
76. Chen S, Gao G, Xia Y, Wu Z. Incidence rate and risk factors of ventilator-associated pneumonia in patients with traumatic brain injury: a systematic review and meta-analysis of observational studies. *J Thorac Dis* [Internet]. 2023 Apr;15(4):2068–78. Available from: <https://doi.org/10.21037/jtd-23-425>
77. Griffin GD. The Injured Brain: TBI, mTBI, the Immune System, and Infection: Connecting the Dots. *Mil Med* [Internet]. 2011 Apr;176(4):364–8. Available from: <https://doi.org/10.7205/milmed-d-10-00021>
78. Robba C, Rebora P, Banzato E, Wieggers EJA, Stocchetti N, Menon DK, et al. Incidence, Risk Factors, and Effects on Outcome of Ventilator-Associated Pneumonia in Patients With Traumatic Brain Injury. *Chest* [Internet]. 2020

Dec;158(6):2292–303. Available from:

<https://doi.org/10.1016/j.chest.2020.06.064>

79. Muscedere J, Sinuff T, Heyland DK, Dodek PM, Keenan SP, Wood G, et al. The Clinical Impact and Preventability of Ventilator-Associated Conditions in Critically Ill Patients Who Are Mechanically Ventilated. *Chest* [Internet]. 2013 Nov;144(5):1453–60. Available from: <https://doi.org/10.1378/chest.13-0853>
80. Nair GB, Niederman MS. Ventilator-associated pneumonia: present understanding and ongoing debates. *Intensive Care Med* [Internet]. 2015 Jan 27;41(1):34–48. Available from: <https://doi.org/10.1007/s00134-014-3564-5>
81. Lim C-K, Ruan S-Y, Lin F-C, Wu C-L, Chang H-T, Jerng J-S, et al. Effect of Tracheostomy on Weaning Parameters in Difficult-to-Wean Mechanically Ventilated Patients: A Prospective Observational Study. Ecker T, editor. *PLoS One* [Internet]. 2015 Sep 17;10(9):e0138294. Available from: <https://doi.org/10.1371/journal.pone.0138294>
82. Pierson DJ. Tracheostomy and weaning. *Respir Care* [Internet]. 2005 Apr;50(4):526–33. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/15807916>
83. Szakmany T, Russell P, Wilkes AR, Hall JE. Effect of early tracheostomy on resource utilization and clinical outcomes in critically ill patients: meta-analysis of randomized controlled trials. *Br J Anaesth* [Internet]. 2015 Mar;114(3):396–405. Available from: <https://doi.org/10.1093/bja/aeu440>