Question G63: What are the predictors for developing wound related problems after major orthopedic procedures?

Alfredas Smailys, Carlos Alfredo Bracho, David Rodriguez, Jan Geurts, Andrea Baldini, Augustinas Rimkunas

Response/Recommendation: Important predictors for wound related complications are: Uncontrolled diabetes (Hb1Ac levels >7.7 mg/dL), obesity, presence of multiple comorbidities (ASA class >3), malnutrition, delay in surgery (trauma cases), prolonged operative time, age over 70, male gender, smoking, alcohol abuse, and colonization with Methicillin Resistant *Staphylococcus aureus* (MRSA).

Level of Evidence: Strong

Delegate Vote:

Rationale: The identification of risk factors for wound-related complications, such as persistent wound drainage (PWD), wound dehiscence, delayed healing, and surgical site infections (SSI), is critical in the context of major orthopedic surgeries. These complications increase mortality and morbidity, prolong hospital stays, and elevate healthcare costs following procedures such as total hip (THA) and knee arthroplasty (TKA), as well as femoral and tibial fracture fixation.

In order to identify these factors, a comprehensive literature review and screening were conducted using Scopus and PubMed databases. The initial screening identified 1,948 studies, of which 83 were included after a detailed review. The review focused on major orthopedic procedures, including hip and knee arthroplasties, as well as femoral and tibial fracture osteosynthesis in the adult population. A qualitative analysis identified 111 risk factors. Only the most prevalent risk factors with highest evidence are discussed. Where odds ratios are provided, they represent the weighted mean of the mean of odds ratios (wOR) reported across the studies.

The overall wound-related complication rate was 3.61% in major orthopedic procedures, with 23,466 complications reported in the selected articles out of a total of 649,911 patients.

Diabetes, particularly when uncontrolled, emerged as the most frequently studied risk factor, with an average weighted odds ratio (wOR) of 1.47. Studies generally encompass diabetes mellitus as both type 1 and type 2.[1–3] Moderate evidence supports diabetes as a significant risk factor after multivariate adjustment. [1,3,4] However, some studies report controversial findings, as significance disappears after analyzing for confounding variables.[2,5] Strong evidence identifies glycated hemoglobin (HbA1c) levels >7.7 mg/dL as a significant risk factor for wound complications. (wOR 2.39)[6–8] Meanwhile, fructosamine was reported to better reflect glycemic control and predict adverse events compared with HbA1c.[9] Fructosamine level of 293 µmol/L was identified as the optimal cut-off associated with complications.[9,10] Patients with elevated levels were reported to be 6.7 to 11.2 times more likely to develop periprosthetic joint infection (PJI).[9,10] Preoperative blood glucose levels was associated with 1.5 times greater odds of PJI were reported as 277 mg/dL for patients with diabetes and 193 mg/dL for those without diabetes.[11]

Obesity was also found to be strongly associated with wound complications.[2,12,13] The weighted odds ratio across studies is 1.70 for patients with a body mass index (BMI) of 30 kg/m^2 or higher, rising to 2.26 for those with a BMI of 40 kg/m^2 or above.

Strong evidence links the American Society of Anesthesiologists (ASA) Physical Status Classification class >3 to wound complications, with most studies reporting significant associations (wOR 1.99).[3,14] A subset of studies employing multivariate analysis has reported that individual conditions, such as cardiovascular disease or chronic renal and hepatic dysfunction, are not significant independent predictors of wound complications.[15,16] In contrast, other studies examining end-stage renal disease (ESRD) have identified an increased risk of infection following THA, with a hazard ratio of up to 2.91 for early infections.[17,18] Similarly, individual studies have reported elevated risk of surgical site infections in patients with liver disease and chronic venous insufficiency.[19,20] These conflicting findings highlight the importance of comprehensive tools, such as the ASA classification, in assessing cumulative risk. However, individual comorbidities may require separate, thorough analyses of specific complications to form strong recommendations.

Malnutrition is a well-established risk factor for wound complications, with strong evidence identifying it as significant (wOR 1.85) across included studies.[21,22] In the literature, it is defined through methods, including serological markers, anthropometric measurements, and nutrition scoring tools, with serum albumin levels <3.5 g/dL and serum total lymphocyte counts (TLC) <1500 cells/mm^3 being the most used criteria.[22] Lower total lymphocyte count values were reported to be significantly associated with delayed wound healing (wOR 1.51).[23] Similarly, serum albumin levels below 3.5 g/dL are strongly supported as a significant risk factor (wOR 1.96).[24,25] Additionally, moderate evidence highlights the albumin-fibrinogen ratio as a potential risk factor (wOR 4.06).[26] Nutritional indexes have demonstrated effectiveness in assessing nutritional status and predicting postoperative complications, such as Onodera's prognostic nutritional index (OPNI), which is composed of serum albumin and total lymphocyte count within the equation.[27] These findings emphasize the critical role of nutritional status in wound healing, underscoring the importance of incorporating nutritional assessment into preoperative risk evaluations.

Factors related to the procedure can be directly influenced by the medical team, offering opportunities to mitigate risks. Strong evidence identifies prolonged time to operation as a significant risk factor (wOR 2.87).[5,28] Wound infection in an elderly population was reported in 2.3% of cases, with surgical delays exceeding 24 hours identified as a significant risk factor (OR 3.48; 95% CI 1.1–10.8; p = 0.023).[28] Moderate evidence associates the prolonged duration of surgery with wound complications (wOR 1.62).[14,29] Prolonged duration of surgery is defined variously across studies, necessitating consideration of methodological differences. The mean operative duration for TKA complicated by SSI was reported to be significantly longer at 90.5 ± 28.2 minutes compared to 72.2 ± 20.3 minutes for TKA without SSI.[30] Operative times exceeding 135 minutes were reported to be associated with an increased risk of both wound and systemic complications.[14] While the exact cutoff for surgical duration is yet to be determined for specific procedures and regions, it is well established that shorter operative times are preferable.

The use of an external fixator is supported by moderate evidence as a risk factor (wOR 3.09).[4,31] However, external fixator use reflects the severity of the injury and was developed to allow soft

tissue recovery before definitive fixation, addressing the unacceptably high infection rates associated with early attempts at plate fixation.[31] Therefore, labeling external fixation as a risk factor is misleading, while its use should be reserved for complex cases to balance the benefits against potential risks.

Postoperative observations can offer valuable insights into potential infections. Moderate evidence identifies persistent postoperative wound drainage as an independent risk factor for surgical site infection.[32,33] Drainage persisting into the second week was reported as the strongest risk factor for joint infection, with an OR of 50.83 (95% CI 11.41–226.51).[33] Evidence for postoperative hematoma as a risk factor remains limited. [34] While moderate evidence identifies revision surgery as a risk factor (wOR 5.02). [35]

Strong evidence supports increased age as a demographic risk factor for wound complications (wOR 1.83). [2,36] Age over 70 was identified as an independent risk factor for surgical site infections, with an adjusted OR of 2.85 (95% CI 1.26–6.43; p = 0.0118).[36] Gender may also influence postoperative wound complications, with moderate evidence supporting male sex as an independent risk factor (wOR 1.52).[3,37] Smoking and alcohol abuse are supported by moderate evidence as independent risk factors, with weighted average odd ratios of 3.31 and 1.59, respectively. [3,35]

Strong evidence associates surgical site infections with methicillin-resistant Staphylococcus aureus (MRSA) (wOR 9.03).[4,37,38] History of MRSA infection or colonization was identified as the most significant predictor of infection (OR 7.20; 95% CI 2.61–19.85; p < 0.001).[4] A positive nasal swab for MRSA has also been reported as a predictor of infection.[37,38]

Conslusions: This comprehensive systematic review identified some important risk factors that may influence wound related complications after major orthopedic procedures. Identifying and addressing the associated risk is pivotal for optimizing preoperative patient management and improving outcomes. By recognizing potential risks, healthcare providers can implement targeted interventions to minimize postoperative wound complications and better inform patients and their families about anticipated outcomes.

1. Golub IJ, Lam AW, Ciminero ML, Vakharia RM, Cannada LK, Kang KK. Comparison study of patient demographics and risk factors for infections following primary total hip arthroplasty for femoral neck fractures. *Arch Orthop Trauma Surg*. 2022;142(12):3779-3786. doi:10.1007/s00402-021-04237-9

2. Eriksson HK, Lazarinis S. Patient-related factors associated with superficial surgical site infection and progression to a periprosthetic joint infection after elective primary total joint arthroplasty: a single-centre, retrospective study in Sweden. *BMJ Open*. 2022;12(9). doi:10.1136/bmjopen-2022-060754

3. Namba RS, Inacio MCS, Paxton EW. Risk factors associated with deep surgical site infections after primary total knee arthroplasty: An analysis of 56,216 knees. *Journal of Bone and Joint Surgery*. 2013;95(9):775-782. doi:10.2106/JBJS.L.00211

4. Reese SM, Knepper B, Young HL, Mauffrey C. Development of a surgical site infection prediction model in orthopaedic trauma: The Denver Health Model. *Injury*. 2017;48(12):2699-2704. doi:10.1016/j.injury.2017.10.011

5. Lau ACK, Neo GH, Lee HC. Risk factors of surgical site infections in hip hemiarthroplasty: A single-institution experience over nine years. *Singapore Med J*. 2014;55(10):535-538. doi:10.11622/smedj.2014137

6. Kieruzel N, Sethi S, Nair V, Wolf JM, Strelzow JA. Do preoperative glucose levels predict risk of complications in orthopaedic surgery? *European Journal of Orthopaedic Surgery and Traumatology*. 2024;34(6):2941-2947. doi:10.1007/s00590-024-04008-3

7. Cancienne JM, Werner BC, Browne JA. Is There a Threshold Value of Hemoglobin A1c That Predicts Risk of Infection Following Primary Total Hip Arthroplasty? *Journal of Arthroplasty*. 2017;32(9):S236-S240. doi:10.1016/j.arth.2017.01.022

8. Tarabichi M, Shohat N, Kheir MM, et al. Determining the Threshold for HbA1c as a Predictor for Adverse Outcomes After Total Joint Arthroplasty: A Multicenter, Retrospective Study. *Journal of Arthroplasty*. 2017;32(9):S263-S267.e1. doi:10.1016/j.arth.2017.04.065

9. Shohat N, Tarabichi M, Tan TL, et al. 2019 John Insall Award: Fructosamine is a better glycaemic marker compared with glycated haemoglobin (HbA1C) in predicting adverse outcomes following total knee arthroplasty. *Bone Joint J*. 2019;101:3-9. doi:10.1302/0301-620X.101B7

10. Shohat N, Goswami K, Breckenridge L, et al. Fructosamine is a valuable marker for glycemic control and predicting adverse outcomes following total hip arthroplasty: a prospective multi-institutional investigation. *Sci Rep*. 2021;11(1). doi:10.1038/s41598-021-81803-6

11. Wier J, Liu KC, Richardson MK, et al. Higher Blood Glucose Levels on the Day of Surgery Are Associated with an Increased Risk of Periprosthetic Joint Infection after Total Hip Arthroplasty. *Journal of Bone and Joint Surgery*. 2024;106(4):276-287. doi:10.2106/JBJS.23.00546

12. Kumar D, Mahendra M, Verma S, Raj R, Kumar A, Kumar A. Incidence and risk factors associated with surgical site infection in acetabular fracture patients: An experience from north India. *J Clin Orthop Trauma*. 2024;52. doi:10.1016/j.jcot.2024.102433

13. Sigurdardottir M, Sigurdsson MI, Vias RD, et al. Preoperative optimization of modifiable risk factors is associated with decreased superficial surgical site infections after total joint arthroplasty: a prospective case-control study. *Acta Orthop*. 2024;95:392-400. doi:10.2340/17453674.2024.41012

14. Belmont PJ, Goodman GP, Waterman BR, Bader JO, Schoenfeld AJ. Thirty-day postoperative complications and mortality following total knee arthroplasty : Incidence and risk factors among a national sample of 15,321 patients. *Journal of Bone and Joint Surgery*. 2014;96(1):20-26. doi:10.2106/JBJS.M.00018

15. Wu C, Qu X, Liu F, Li H, Mao Y, Zhu Z. Risk factors for periprosthetic joint infection after total hip arthroplasty and total knee arthroplasty in Chinese patients. *PLoS One*. 2014;9(4). doi:10.1371/journal.pone.0095300

16. Golub IJ, Lam AW, Ciminero ML, Vakharia RM, Cannada LK, Kang KK. Comparison study of patient demographics and risk factors for infections following primary total hip arthroplasty for femoral neck fractures. *Arch Orthop Trauma Surg*. 2022;142(12):3779-3786. doi:10.1007/s00402-021-04237-9

17. Fox JA, Domingue GA, DeMaio C V., Brockman BS, Malloy K, Thakral R. Total hip arthroplasty complications in patients with chronic kidney disease: A comparison study. *J Orthop*. 2023;39:1-6. doi:10.1016/j.jor.2023.03.013

18. Malkani JA, Heimroth JC, Ong KL, et al. Complications and Readmission Incidence Following Total Hip Arthroplasty in Patients Who Have End-Stage Renal Failure. *Journal of Arthroplasty*. 2020;35(3):794-800. doi:10.1016/j.arth.2019.10.042

19. Summers S, Yakkanti R, Ocksrider J, et al. Effects of Venous Insufficiency in Patients Undergoing Primary Total Knee Arthroplasty: An Analysis of 1.2 Million Patients. *J Knee Surg*. 2023;3(36):322-328.

20. Kinnard MJ, Cohen JS, Quan T, Foran JRH, Sheth NP. Liver Disease Increases the Risk of Postoperative Complications in Patients Undergoing Aseptic Revision Total Hip and Knee Arthroplasty. *Arthroplast Today*. 2024;29. doi:10.1016/j.artd.2024.101516

21. Fang CJ, Saadat GH, Butler BA, Bokhari F. The Geriatric Nutritional Risk Index Is an Independent Predictor of Adverse Outcomes for Total Joint Arthroplasty Patients. *Journal of Arthroplasty*. 2022;37(8):S836-S841. doi:10.1016/j.arth.2022.01.049

22. Morey VM, Song YD, Whang JS, Kang YG, Kim TK. Can Serum Albumin Level and Total Lymphocyte Count be Surrogates for Malnutrition to Predict Wound Complications After Total Knee Arthroplasty? *Journal of Arthroplasty*. 2016;31(6):1317-1321. doi:10.1016/j.arth.2015.12.004

23. Guo JJ, Yang H, Qian H, Huang L, Guo Z, Tang T. The Effects of Different Nutritional Measurements on Delayed Wound Healing After Hip Fracture in the Elderly. *Journal of Surgical Research*. 2010;159(1):503-508. doi:10.1016/j.jss.2008.09.018

24. Haro-Gomez HL, Merida-Herrera E, Torres-Fernandez BJ, Perez-Hernandez E, Torres-Gonzalez R, Perez-Antanasio JM. *Preoperative Serum Albumin as a Predictor of Complications Following Total Hip Replacement in Patients with Rheumatoid Arthritis*. Vol 32.; 2018. www.medigraphic.org.mxhttp://www.medigraphic.com/actaortopedicawww.medigraphic.org.mxwww.medigraphic.org.mx

25. Yang G, Zhu Y, Zhang Y, Augustin G. Prognostic risk factors of surgical site infection after primary joint arthroplasty: A retrospective cohort study. *Medicine (United States)*. 2020;99(8). doi:10.1097/MD.0000000000019283

26. Aslam S, Reitman C, Darouiche RO. Risk Factors for Subsequent Diagnosis of Prosthetic Joint Infection. *Infect Control Hosp Epidemiol*. 2010;31(3):298-301. doi:10.1086/650756

27. Cross MB, Yi PH, Thomas CF, Garcia J, Della Valle CJ. Evaluation of Malnutrition in Orthopaedic Surgery. *JAAOS - Journal of the American Academy of Orthopaedic Surgeons*. 2014;22(3). https://journals.lww.com/jaaos/fulltext/2014/03000/evaluation_of_malnutrition_in_orthopaedic_surgery.7.aspx

28. Cordero J, Maldonado A, Iborra S. Surgical delay as a risk factor for wound infection after a hip fracture. *Injury*. 2016;47:S56-S60. doi:10.1016/S0020-1383(16)30607-6

29. Zajonz D, Brand A, Lycke C, et al. Risk factors for early infection following hemiarthroplasty in elderly patients with a femoral neck fracture. *European Journal of Trauma and Emergency Surgery*. 2019;45(2):207-212. doi:10.1007/s00068-018-0909-8

30. Teo BJX, Yeo W, Chong HC, Tan AHC. Surgical site infection after primary total knee arthroplasty is associated with a longer duration of surgery. *Journal of Orthopaedic Surgery*. 2018;26(2). doi:10.1177/2309499018785647

31. Parkkinen M, Madanat R, Lindahl J, Mäkinen TJ. Risk factors for deep infection following plate fixation of proximal tibial fractures. *Journal of Bone and Joint Surgery - American Volume*. 2016;98(15):1292-1297. doi:10.2106/JBJS.15.00894

32. Marculescu CE, Cantey JR. Polymicrobial prosthetic joint infections: Risk factors and outcome. In: *Clinical Orthopaedics and Related Research*. Vol 466. Springer New York; 2008:1397-1404. doi:10.1007/s11999-008-0230-7

33. Scheper H, Mahdad R, Elzer B, et al. Wound drainage after arthroplasty and prediction of acute prosthetic joint infection: Prospective data from a multicentre cohort study using a telemonitoring app. *J Bone Jt Infect*. 2023;8(1):59-70. doi:10.5194/jbji-8-59-2023

34. da Silva RB, Salles MJ. Outcomes and risk factors in prosthetic joint infections by multidrug-resistant gram-negative bacteria: A retrospective cohort study. *Antibiotics*. 2021;10(3). doi:10.3390/antibiotics10030340

35. Simon S, Hollenbeck B. Risk factors for surgical site infections in knee and hip arthroplasty patients. *Am J Infect Control*. 2022;50(2):214-216. doi:10.1016/j.ajic.2021.11.006

36. Brophy RH, Bansal A, Rogalski BL, et al. Risk Factors for Surgical Site Infections after Orthopaedic Surgery in the Ambulatory Surgical Center Setting. *Journal of the American Academy of Orthopaedic Surgeons*. 2019;27(20):E928-E934. doi:10.5435/JAAOS-D-17-00861

37. Wise BT, Connelly D, Rocca M, et al. A Predictive Score for Determining Risk of Surgical Site Infection after Orthopaedic Trauma Surgery. *J Orthop Trauma*. 2019;33(10):506-513. doi:10.1097/BOT.0000000000001513

38. Everhart JS, Altneu E, Calhoun JH. Medical comorbidities are independent preoperative risk factors for surgical infection after total joint arthroplasty. In: *Clinical Orthopaedics and Related Research*. Vol 471. Springer New York LLC; 2013:3112-3119. doi:10.1007/s11999-013-2923-9