Chronic liver disease (CLD) is one of the most common ailments involving the hepatobiliary system. It is a common cause of mortality and morbidity worldwide. Liver cirrhosis is the end stage of CLDs characterized by scarring, architectural distortion, and progressive depletion of the liver's functional reserve. Viral hepatitis and alcohol abuse are the most common causes of CLD with non-alcoholic steatohepatitis emerging as an important precipitating factor.

Both CLD and cirrhosis are associated with numerous multi-system complications, including musculoskeletal diseases, hormonal, cardiac, and nervous system complications. Many factors contribute to these complications, such as hepatic osteodystrophy (HO), increased infection susceptibility, sarcopenia, osteonecrosis of the femoral head (OFH), increased risk of periprosthetic complications and fracture. Hepatic osteodystrophy, which comprises osteopenia, osteoporosis, and osteomalacia, refers to alterations in bone mineral metabolism found in patients with CLD. The HO prevalence ranges from 13 to 95%. Low complement levels, poor opsonization capacity, portosystemic shunting, decreased albumin levels, and impaired reticuloendothelial system make the cirrhotic patients more susceptible to developing infectious diseases. Septic arthritis, osteomyelitis, prosthetic joint infection, and cellulitis were common types of CLD-associated infectious conditions. The incidence of septic arthritis is 1.5 to 2-fold higher in patients with cirrhosis. Sarcopenia, also known as muscle wasting, is one of the frequently overlooked manifestations of CLD. Sarcopenia has been shown to be an independent predictor of longer mechanical ventilation, hospital stay, and 12-month mortality of post-transplantation. Alcohol and steroid abuse commonly associated with CLD are the two most important contributory factors for non-traumatic osteonecrosis. However, many studies have identified cirrhosis alone to be an independent cause of atraumatic osteonecrosis. The risk of developing OFH in cirrhosis patients increases by 2.4 folds and the need for total hip arthroplasty increases by 10 folds. Liver disease has been associated with worse outcomes and higher costs after arthroplasty. Cirrhosis is a risk factor for arthroplasty complications and is associated with a prolonged hospital stay, higher costs, readmission rates, and increased mortality after arthroplasty. Greater physician awareness of risk factors associated with musculoskeletal complications of CLD patients would yield earlier interventions, lower healthcare costs, and better overall clinical outcomes for this group of patients.

**Keywords:** Femur head necrosis, liver diseases, osteoporosis, sarcopenia.
Musculoskeletal disorders in liver disease

Hepatic osteodystrophy refers to the group of alterations in bone mineral metabolism found in patients with CLD. The umbrella of HO comprises osteopenia, osteoporosis, and osteomalacia.[3] The prevalence of HO ranges from as low as 13% to as high as 95%.[4,5] A higher prevalence is reported in the Indian population, i.e., from 68 to 95% versus 13 to 70% in Western countries.

Current studies have shown that almost 75% of patients with CLD have severe osteoporosis.[6,7] Hepatic osteodystrophy eventually results in the reduction of bone mineral density (BMD) and deterioration of the bone structure, for instance, trabecular architecture or bone geometry. These alterations in bone structure increase the risk of fragility fractures in patients with HO.[8,9] With alcoholism being an independent factor for the development of osteoporosis, overall, 35.9% of patients having alcoholic liver disease show altered bone metabolism and structure.[10,11]

In a study conducted by Choudhary et al.[12] with 115 cirrhosis patients with a mean age of 49 years on HO, which is one of the most common pathologies associated with CLD in the literature, only 4.5% of the patients had normal bone density and that osteoporosis (38.2%) or osteopenia (57.3%) was detected in all of the remaining patients. In the study conducted by Hajiabbasi et al.,[13] 97 patients with a mean age of 51 years were investigated, and vitamin D deficiency was found in 80.2% of the patients. Besides, 45.4% patients had osteopenia and 33% had osteoporosis. After adjusting for variables in a six-variable model, such as age, sex, body mass index (BMI), Child-Pugh score, current smoking status, estimated glomerular filtration rate (eGFR), and vitamin D level, lower vitamin D, higher Child-Pugh score, and lower eGFR values were reported to significantly increase the risk of abnormal dual-energy X-ray absorptiometry (DXA) results. Also, in a study conducted by Savic et al.[14] with 30 male patients, osteoporosis was detected in 20% of the patients and a statistically significant relationship between osteoporosis and disease severity and vitamin D status could not be determined.

Wang et al.,[15] in their study, demonstrated a significant association between non-alcoholic fatty liver disease and osteoporotic fracture risk in older Chinese men.[16] Tsai et al.[17] in their study of 4,000 patients with cirrhosis of mixed etiologies demonstrated an increased risk and cumulative increased incidence of fractures in such patients. Regardless of the etiology, the prevalence and severity of HO are positively correlated with the duration and severity of the liver disease. Several risk factors have been postulated for disease development including age, BMI, duration and severity of the underlying disease, overall low BMD with a history of fragility fractures, malnutrition, genetic predisposition, hormonal status, iron and copper accumulation, hyperbilirubinemia, alterations in vitamin status, and the effects of the used medications.[18] However, they neither give any information about the onset of HO nor about its severity. Early assessment of BMD by DXA, particularly of the lumbar spine and femoral neck, is essential to prevent fracture risk. Fracture risk can be minimized by correcting the reversible risk factors with early diagnosis of HO. Treatment and prevention strategies include lifestyle changes, dietary modifications, including stopping alcohol consumption, and medications (calcium/vitamin D/bisphosphonates).

Osteoporosis is usually asymptomatic. However, it increases the risk of bone fractures due to low-energy
Infections are commonly associated with CLD. Patients with CLD have impaired immunity and metabolic derangements. In patients with CLD, there is a breach in the intestinal portal barrier with bacterial overgrowth resulting in bacterial translocation. Also, low complement levels, poor opsonization capacity, portosystemic shunting, decreased albumin levels, and impaired reticuloendothelial system make the cirrhotic patients more susceptible to developing infectious diseases. Septic arthritis, osteomyelitis, spondylodiscitis, prosthetic joint infection, cellulitis, and necrotizing fasciitis (NF) are the most common types of CLD-associated infectious conditions.

**Septic arthritis:** The hip, knee, and shoulder are the most commonly affected joints in patients with CLD due to their abundant metaphyseal blood supply. The patient with septic arthritis presents with the usual symptoms of pain, swelling over the affected joint along with the limitation of range of motion and diagnostic management, also similar to non-CLD patients. Magnetic resonance imaging (MRI) plays an important part in the early detection of septic arthritis and guiding its subsequent treatment, thereby, preventing irreversible joint damage. Therefore, in patients with CLD and fever and limitation of joint movements, we should have a high suspicion of septic arthritis to diagnose and treat it promptly.

In the study conducted by Hung et al., 35,106 adult cirrhosis patients without a history of septic arthritis or prosthetic joints and 33,457 non-cirrhotic patients were followed for three years. The incidence of septic arthritis was approximately two-fold higher in patients with cirrhosis than patients without cirrhosis (p=0.001). Besides, it was found that the risk of developing septic arthritis increased by 1.5 times in patients with complicated cirrhosis, compared to other cirrhosis patients (p=0.003).

**Spondylodiscitis/Osteomyelitis:** In general, CLD patients have an increased incidence of bony infections, particularly of the spine, due to their lower immunity status. Patients usually present with bony pain and swelling. In a study conducted by Kim et al., the increased rates of mortality in pyogenic vertebral osteomyelitis in cirrhotic patients were found, and liver function was a strong predictor of mortality in this group of patients. Diagnosis of spondylodiscitis is often delayed or missed due to the preexisting higher frequency of lower back pain in the general population. Therefore, hematological and radiological investigations should be ordered early to help in early diagnosis and to prevent complications. Diminished disc space is the first sign detected on X-ray. Loss of vertebral height and paravertebral abscesses are present in advanced disease. For spondylodiscitis, MRI is the investigation of choice with the decreased signal intensity from the disc and adjoining vertebral bodies on T1 weighted images and signal enhancement on T2 weighted images.

Besides, tissue ischemia eventually leading to higher chances of peripheral gangrene and osteomyelitis can be observed in CLD patients as an adverse effect of advanced liver disease drugs, such as terlipressin. The prevalence of skeletal tuberculosis is also higher in patients with cirrhosis. Therefore, there must be a high index of suspicion of extrapulmonary bony involvement in tubercular cirrhotic patients.

**Cellulitis:** Cellulite, which is also common in the general population, occurs in approximately 12.5% of cirrhotic patients. The risk of cellulitis increases in patients with cirrhosis, and this risk further increases in complicated cases. Skin edema in the lower extremities is a common finding in patients with CLD, and chronic edema predisposes to infections. In cirrhosis patients, skin erythematous disorders or other symptoms and/or signs of infection should be detected and treated early to prevent serious infectious diseases. In the study by Lin et al., 39,966 patients with cirrhosis and 39,701 demographically-matched, randomly selected individuals were observed for three years, and cellulitis was statistically significantly higher in those with cirrhosis (6.7%) compared to the control group (4.0%) (p<0.001).

**Necrotizing fasciitis:** Necrotizing fasciitis is a rapidly progressive soft tissue infection that spreads along the fascial planes. It is most commonly a polymicrobial infection. Liver cirrhosis has been identified to be a common underlying disease for NF in many studies. In cirrhotic patients, NF is associated with a poor prognosis, despite advanced treatments currently. In a retrospective study of cirrhosis patients diagnosed with NF by Cheng et al., infection prognosis often
ended with death in patients with Grade C cirrhosis (p=0.028) and those with diabetes mellitus (p=0.043). In addition, Huang et al.[32] reported around nine-fold higher mortality rates of NF with cirrhosis compared to NF without cirrhosis.

SARCOPENIA

Sarcopenia, also known as muscle wasting, is one of the frequently overlooked manifestations of CLD. It is defined as a muscle mass two standard deviations below that of the mean muscle mass of healthy young adult reference groups.[22] It has a poor prognosis, as it is frequently associated with falls, fractures, and ineffective response to stresses including infections and surgeries. Sarcopenia is caused due to malnutrition frequently associated with CLD. Ineffective nutrient metabolism, inadequate oral intake due to early satiety associated with CLD, associated ascites and metabolic derangements are the key factors contributing to malnutrition.[33]

Sarcopenia has an impaired effort tolerance with a negative influence on the quality of life and survival; therefore, its early identification and appropriate management are crucial. Functional assessment of sarcopenia is performed by the handgrip strength and walking speed (WS). Currently, the European Working Group on Sarcopenia in Older People (EWGSOP) criteria and the Asian Working Group on Sarcopenia (AWGS) criteria define 0.8 m/s as the cut-off point for WS decline. In a study by Nishikawa et al.,[34] they categorized extracellular fluid excess based on the extracellular water-to-total body water ratio and found it to be closely linked to WS decline in CLD patients.[34]

Muscle mass has been objectively assessed by different techniques such as the bioimpedance analysis, DXA, computed tomography (CT), and MRI, out of which the L3 skeletal muscle index (L3SMI) expressed as cross-sectional muscle area height is found to be most useful. For calculating the L3SMI, a CT scan at the level of the third lumbar vertebra is analyzed with the help of commercially available software, which enables specific tissue demarcation using previously reported Hounsfield unit (HU) thresholds.[33]

In a study by Montano-Loza et al.[35] investigating the relationship between cirrhosis and sarcopenia on 120 patients with cirrhosis, L3SMI was measured, and sarcopenia was detected in 40% of the patients, and sarcopenia was reported to be a risk factor associated with mortality. Malnutrition and sarcopenia were shown to be independent predictors of longer mechanical ventilation, longer intensive care unit and hospital stay, increased incidence of infections, and 12-month mortality of post-transplantation in a study conducted by Kalafateli et al.[36] in 232 patients who underwent liver transplantation due to end-stage liver disease.

OSTEONECROSIS OF THE FEMORAL HEAD

Alcohol and steroid abuse commonly associated with CLD are the two main contributory factors for non-traumatic osteonecrosis. However, many studies have identified cirrhosis alone to be an independent cause of atraumatic osteonecrosis.[37-39] Various mechanisms have been postulated to demonstrate the association between cirrhosis and osteonecrosis, which include coagulopathy, endothelial dysfunction, and chronic inflammation.[38] Interleukin-33 and interleukin-6 (T-lymphocyte activators) have been linked to both cirrhosis and osteonecrosis along with the presence of hyperdynamic circulation in cirrhotic patients that facilitates diffusion of proinflammatory cytokines and endotoxins throughout the body.[40] The MRI is the investigation of choice, particularly in the early stages of OFH. Total hip replacement is the most routinely performed surgical procedure for OFH in cirrhotic patients. However, the absolute risks of surgery are markedly higher in these patients than in reference individuals.[41]

In the study conducted by Hung et al.,[38] which followed 40,769 cirrhotic patients and randomly selected 40,769 sex- and age-matched non-cirrhotic patients without baseline OFH for three years, OFH was detected in three of 1,000 cirrhotic patients and 1.1 of 1,000 patients in the control group (p<0.001, hazard ratio: 2.38). Besides, in a Danish Hip Arthroplasty Registry-based study which included 23,421 cirrhosis patients and 114,052 reference individuals, the risk of undergoing total hip replacement surgery due to OFH increased by 10-folds in cirrhotic patients.[41]

PERIPROSTHETIC COMPLICATIONS

Liver disease has been associated with worse outcomes and higher costs after arthroplasty. A number of studies have also identified cirrhosis as a risk factor for arthroplasty complications; cirrhosis is associated with a longer hospital stay, higher costs, readmission rates, and increased mortality after arthroplasty.[42] Increased rates of periprosthetic/peri-implant infections have been observed in patients with comorbidities such as
cirrhosis.\textsuperscript{[43,44]} The severity of liver damage is positively associated with higher rates of infections. In a study performed by Jiang et al.,\textsuperscript{[45]} as a nationwide status and investigating periprosthetic infections, the probability of periprosthetic infection in cirrhosis patients was 3.4-times increased (p<0.001) after total knee prosthesis, 5.4-times (p<0.001) after total hip prosthesis, and 5.8-times in prostheses performed after hip fracture (p<0.001). In the review by Onochie et al.,\textsuperscript{[46]} 28,495 patients who underwent total hip arthroplasty were evaluated, and the infection rate was reported as 0.5% and the reoperation rate was 4% (46/1,083).

These patients usually present with pain and discharge around the operative site. Patients with cirrhosis have a longer length of hospital stay, increased costs, increased transfusion requirements, and higher rates of mortality, readmission, and reoperation. Also, higher rates of periprosthetic infections are reported in total knee arthroplasty compared to total hip arthroplasty. Among cirrhotic patients of total hip arthroplasty, higher rates of infection are reported for hip fractures (3.7%) than for non-hip fracture diagnosis (0.7%).\textsuperscript{[45-49]}

In conclusion, the current review identifies multiple significant musculoskeletal complications related to CLD. The three most common complications associated with CLD are HO, infections (septic arthritis, spondylodiscitis, prosthetic joint infection), and sarcopenia. Greater physician awareness of risk factors associated with musculoskeletal complications of CLD patients would yield earlier interventions, lower cost of healthcare, and better overall clinical outcomes for this group of patients.

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REFERENCES
1. Ly KN, Speers S, Klevens RM, Barry V, Vogt TM. Measuring chronic liver disease mortality using an expanded cause of death definition and medical records in Connecticut, 2004. Hepatol Res 2015;45:960-8.
2. Neff GW, Duncan CW, Schiff ER. The current economic burden of cirrhosis. Gastroenterol Hepatol (N Y) 2011;7:661-71.
3. Nakchbandi IA, van der Merwe SW. Current understanding of osteoporosis associated with liver disease. Nat Rev Gastroenterol Hepatol 2009;6:660-70.
4. Wright NC, Looker AC, Saag KG, Curtis JR, Delzell ES, Randall S, et al. The recent prevalence of osteoporosis and low bone mass in the United States based on bone mineral density at the femoral neck or lumbar spine. J Bone Miner Res 2014;29:2520-6.
5. Bozkurt HH, Tokgöz MA, Yapaş A, Atık OŞ. What is the importance of canal-to-diaphysis ratio on osteoporosis-related hip fractures? Eklem Hastalik Cerrahisi 2019;30:296-300.
6. Rouillard S, Lane NE. Hepatic osteodystrophy. Hepatology 2001;33:301-7.
7. George J, Ganesh HK, Acharya S, Bandgar TR, Shivane V, Karvat A, et al. Bone mineral density and disorders of mineral metabolism in chronic liver disease. World J Gastroenterol 2009;15:3516-22.
8. Angulo P, Grandison GA, Fong DG, Keach JC, Lindor KD, Bjornsson E, et al. Bone disease in patients with primary sclerosing cholangitis. Gastroenterology 2011;140:180-8.
9. Guañabens N, Cerdá D, Monegal A, Pons F, Caballería L, Peris P, et al. Low bone mass and severity of cholestasis affect fracture risk in patients with primary biliary cirrhosis. Gastroenterology 2010;138:2348-56.
10. Tsai CF, Liu CJ, Chen TJ, Chu CJ, Lin HC, Lee FY, et al. Increased incidence of orthopedic fractures in cirrhotic patients: A nationwide population-based study. J Hepatol 2013;58:706-14.
11. Chang CH, Chang CJ, Wang YC, Hu CC, Chang Y, Hsieh PH, et al. Increased incidence, morbidity, and mortality in cirrhotic patients with hip fractures: A nationwide population-based study. J Orthop Surg (Hong Kong) 2020;28:230949020918032.
12. Savic Z, Damjanov D, Curic N, Kovacev-Zavisic B, Hadnadjev L, Novakovic-Paro J, et al. Vitamin D status, bone metabolism and bone mass in patients with alcoholic liver cirrhosis. Bratisl Lek Listy 2014;115:573-8.
13. Malik P, Gasser RW, Kemmler G, Moncayo R, Finkenstedt G, Kurz M, et al. Low bone mineral density and impaired bone metabolism in young alcoholic patients without liver cirrhosis: A cross-sectional study. Alcohol Clin Exp Res 2009;33:375-81.
14. Choudhary NS, Tomar M, Chawla YK, Bhadada SK, Khandelwal N, Dhiman RK, et al. Hepatic osteodystrophy is common in patients with noncholestatic liver disease. Dig Dis Sci 2011;56:3323-7.
15. Hajjibashi A, Shafaghhi A, Fayazi HS, Shenavar Masooleh I, Hedayati Emami MH, Ghavidel Parsa P, et al. The factors affecting bone density in cirrhosis. Hepat Mon 2015;15:e26871.
16. Wang Y, Wen G, Zhou R, Zhong W, Lu S, Hu C, et al. Association of nonalcoholic fatty liver disease with osteoporotic fractures: A cross-sectional retrospective study of Chinese individuals. Front Endocrinol (Lausanne) 2018;9:408.
17. Ehnert S, Aspera-Werz RH, Ruöö M, Dooley S, Hengstler JG, Nadalin S, et al. Hepatic osteodystrophy-molecular mechanisms proposed to favor its development. Int J Mol Sci 2019;20:2555.
18. Otete H, Deleuran T, Fleming KM, Card T, Aithal GP, Jepsen P, et al. Hip fracture risk in patients with alcoholic cirrhosis: A population-based study using English and Danish data. J Hepatol 2018;69:697-704.
19. Hamza RE, Villyth MP, Peter G, Joseph D, Govindaraju C, Tank DC, et al. Risk factors of cellulitis in cirrhosis...
and antibiotic prophylaxis in preventing recurrence. Ann Gastroenterol 2014;27:374-9.

20. Rocco A, Compare D, Angrisani D, Sanduzzi Zamparelli M, Nardone G. Alcoholic disease: Liver and beyond. World J Gastroenterol 2014;20:14652-9.

21. Malnick SD, Attali M, Israeli E, Gratz R, Geltner D. Spontaneous bacterial arthritis in a cirrhotic patient. J Clin Gastroenterol 1998;27:364-6.

22. Arora A, Rajesh S, Bansal K, Sureka B, Patidar Y, Thapar S, et al. Cirrhosis-related musculoskeletal disease: Radiological review. Br J Radiol 2016;89:20150450.

23. Hung TH, Hsieh MH, Lay CJ, Tsai CC, Tsai CC. Increased occurrence of native septic arthritis in adult cirrhotic patients: A population-based three-year follow-up study in Taiwan. Prz Gastroenterol 2014;9:342-7.

24. Rajesh G, Mehta R, Nandakumar R, Sadasivan S, John A, Balakrishnan N. Skeletal infections in cirrhotics. Indian J Gastroenterol 2005;24:174-5.

25. Kim J, Kang HS, Kim JW, Kim SW, Oh JK, Kim YW, et al. Treatment outcomes in patients with pyogenic vertebral osteomyelitis who have cirrhosis. Sci Rep 2019;9:15223.

26. Lee HJ, Oh MJ. A case of peripheral gangrene and osteomyelitis secondary to terlipressin therapy in advanced liver disease. Clin Mol Hepatol 2013;19:179-84.

27. Sharma P, Tyagi P, Singla V, Bansal N, Kumar A, Arora A. Clinical and biochemical profile of tuberculous in patients with liver cirrhosis. J Clin Exp Hepatol 2015;5:8-13.

28. Kim JH, Lee JS, Lee SH, Bae WK, Kim NH, Kim KA, et al. Renal dysfunction induced by bacterial infection other than spontaneous bacterial peritonitis in patients with cirrhosis: Incidence and risk factor. Gut Liver 2009;3:292-7.

29. Mohan P, Ramu B, Bhaskar E, Venkataraman J. Prevalence and risk factors for bacterial skin infection and mortality in cirrhosis. Ann Hepatol 2011;10:15-20.

30. Lin MN, Tsai CC, Hung TH, Tsai CC. The risk of cellulitis in cirrhotic patients: A nationwide population-based study in Taiwan. Gut Liver 2012;6:482-5.

31. Cheng NC, Tai HC, Tang YB, Chang SC, Wang JT. Necrotising fasciitis: Clinical features in patients with liver cirrhosis. Br J Plast Surg 2005;58:702-7.

32. Huang KF, Hung MH, Lin YS, Lu CL, Liu C, Chen CC, et al. Independent predictors of mortality for necrotizing fasciitis: A retrospective analysis in a single institution. J Trauma 2011;71:467-73.

33. Montano-Loza AJ. Clinical relevance of sarcopenia in patients with cirrhosis. World J Gastroenterol 2014;20:8061-71.

34. Nishikawa H, Shiraki M, Hiramatsu A, Moriya K, Hino K, Nishiguchi S. Japan Society of Hepatology guidelines for sarcopenia in liver disease (1st edition): Recommendation from the working group for creation of sarcopenia assessment criteria. Hepatol Res 2016;46:951-63.

35. Montano-Loza AJ, Meza-Junco J, Prado CM, Lieffers JR, Baracos VE, Bain VG, et al. Muscle wasting is associated with mortality in patients with cirrhosis. Clin Gastroenterol Hepatol 2012;10:166-73.

36. Kalafateli M, Mantzoukis K, Choi Yau Y, Mohammad AO, Arora S, Rodrigues S, et al. Malnutrition and sarcopenia predict post-liver transplantation outcomes independently of the Model for End-stage Liver Disease score. J Cachexia Sarcopenia Muscle 2017;8:113-21.

37. Iwakiri Y, Groszmann RJ. Vascular endothelial dysfunction in cirrhosis. J Hepatol 2007;46:927-34.

38. Hung TH, Hsieh YH, Tsai CC, Tseng CW, Tseng KC, Tsai CC. Is liver cirrhosis a risk factor for osteonecrosis of the femoral head in adults? A population-based 3-year follow-up study. Intern Med 2011;50:2563-8.

39. Marvie P, Lisbonne M, L'helgoualc'h A, Rauch M, Turlin B, Preisser L, et al. Interleukin-33 overexpression is associated with liver fibrosis in mice and humans. J Cell Mol Med 2010;14:1726-39.

40. Lee FY, Lu RH, Tsai YT, Lin HC, Hou MC, Li CP, et al. Plasma interleukin-6 levels in patients with cirrhosis. Relationship to endotoxemia, tumor necrosis factor-alpha, and hyperdynamic circulation. Scand J Gastroenterol 1996;31:500-5.

41. Deleuran T, Overgaard S, Vilstrup H, Jepsen P. Cirrhosis is a risk factor for total hip arthroplasty for avascular necrosis. Acta Orthop 2016;87:231-4.

42. Salomon B, Krause PC, Dasa V, Shi L, Jones D, Chapple AG. The impact of hepatitis C and liver disease on risk of complications after total hip and knee arthroplasty: Analysis of administrative data from Louisiana and Texas. Arthroplast Today 2021;7:200-7.

43. Koenig K, Huddleston JJ 3rd, Huddleston H, Maloney WJ, Goodman SB. Advanced age and comorbidity increase the risk for adverse events after revision total hip arthroplasty. J Arthroplasty 2012;27:1402-7.e1.

44. Schairer WW, Vail TP, Bozic KJ. What are the rates and causes of hospital readmission after total knee arthroplasty? Clin Orthop Relat Res 2014;472:248-91.

45. Onochie E, Kayani B, Dawson-Bowling S, Millington S, Goodman AG. The impact of hepatitis C and liver disease on risk of complications after total hip and knee arthroplasty. Clin Orthop Relat Res 2016;87:231-4.

46. Deleuran T, Overgaard S, Vilstrup H, Jepsen P. Cirrhosis is a risk factor for total hip arthroplasty for avascular necrosis. Clin Orthop Relat Res 2014;472:248-91.

47. Schairer WW, Vail TP, Bozic KJ. What are the rates and causes of hospital readmission after total knee arthroplasty? Clin Orthop Relat Res 2014;472:248-91.

48. Onochie E, Kayani B, Dawson-Bowling S, Millington S, Goodman AG. The impact of hepatitis C and liver disease on risk of complications after total hip and knee arthroplasty. Clin Orthop Relat Res 2014;472:248-91.

49. Kılınc S, Tunç T, Pazarçlı Ö, Sümer Z. Research into biocompatibility and cytotoxicity of daptomycin, gentamicin, vancomycin and teicoplanin antibiotics at common doses added to bone cement. Jt Dis Relat Surg 2020;31:449-55.