



ONKOLOJİ HASTALARINDA AKUT BÖBREK HASARINA YAKLAŞIM

Onur TUNCA¹

GİRİŞ

Akut böbrek hasarı (ABH) kanser tanısı almış olan hastalarda oldukça sık karşılaşılan bir durumdur (1,2). Hasarın ciddiyeti kanserin evresine, tipine, uygulanan tedavi yöntemlerine ve eşlik eden komorbid hastalıklara göre değişkenlik gösterebilir (1,3). Tüm bunlara ek olarak hasta takibi sırasında karşılaşılabilen enfeksiyon, sepsis ve kansere bağlı metabolik bozukluklar da ABH'nin azımsanmayacak nedenleri arasında yer almaktadır (4).

Her ne sebeple gelişir ise gelişsin ortaya çıkan renal hasarlanmanın erken tanınması onkolog ve nefrologlar açısından hasta bazında ayrı bir öneme sahiptir. Tanıda yaşanan gecikmeler, hastaların hastanede yatış sürelerini uzatmakta ve hayat konforlarını etkilemektedir (5). Ayrıca ABH'ye bağlı inflamatuvar sitokin salınımının artmasıyla kapiller geçirgenlik bozulmakta ve renal replasman tedavisi (RRT) gerektiren durumlar ile karşılaşılabilirmektedir (5). Kanser tedavisi sırasında uygulanan RRT'nin yaratmış olduğu problem ise kemoterapötik ilaç düzeylerinde yaşanan değişkenliklerdir (5). Bahsi geçen tüm bu istenmeyen durumlar, mevcut tedaviyi sekteye uğrattığı gibi bazen de kritik düzeyde kanser hastalarının tedavilerin sonlandırılmasına neden olabilmektedir (5).

¹ Dr. Öğr Üyesi, Afyonkarahisar Sağlık Bilimleri Üniversitesi, Tıp Fakültesi, İç Hastalıkları AD,
dronurtunca@hotmail.com

Mannitol, kalsiyum kanal blokeri (KKB), bikarbonat ve N-asetil sistein uygulamalarının yararı tartışmalıdır. Korunma önlemleri arasında yeterli hidrasyonun sağlanması ve mümkün ise riskli görülen durumlarda izo-osmolar ajanların tercih edilmesi bulunmaktadır (153).

SONUÇ

Kanser tanısı almış vakalarda gelişen ABH ülkemizde olduğu gibi tüm dünyada da halen büyük bir halk sağlığı problemidir. Mevcut hasarlanma kanserin kendisine ait komplikasyonlardan kaynaklanabildiği gibi verilen tedaviler ile de ilişkili olabilmektedir. Multidisipliner yaklaşım, gelişen teknoloji ve ileri yaşam desteği sayesinde eskiye nazaran oldukça fazla yol katedilmiş durumdadır. ABH açısından risk faktörlerinin iyi analiz edilmesi, hasar etiyolojisinin aydınlatılmadığı durumlarda renal biyopsi gibi girişimsel işlemlerden kaçınılmaması gerekmektedir. Umut ediyoruz ki bu konuda yapılacak yeni çalışmalar ile tanı ve tedavi aşamasında yaşanan zorluklar giderek azalacaktır.

KAYNAKLAR

- Perazella MA, Rosner MH. Acute Kidney Injury in Patients With Cancer. *Oncology (Williston Park, N.Y.)*. 2018;32(7): 351–359. doi:10.1056/nejmra1613984
- Canet E, Zafrani L, Lambert J, et al. Acute kidney injury in patients with newly diagnosed high-grade hematological malignancies: impact on remission and survival. *PloS one*. Public Library of Science; 2013;8(2): e55870.
- Salahudeen AK, Doshi SM, Pawar T, et al. Incidence rate, clinical correlates, and outcomes of AKI in patients admitted to a comprehensive cancer center. *Clinical Journal of the American Society of Nephrology*. Am Soc Nephrol; 2013;8(3): 347–354.
- Meraz-Munoz A, Langote A, D Jhaveri K, et al. Acute Kidney Injury in the Patient with Cancer. *Diagnostics*. Multidisciplinary Digital Publishing Institute; 2021;11(4): 611.
- Lahoti A, Humphreys BD. AKI associated with malignancies. *Onconeurology Curriculum*. 2016;
- César BN, Durão Júnior M de S. Acute kidney injury in cancer patients. *Revista da Associação Médica Brasileira*. SciELO Brasil; 2020;66: s25–s30.
- Christiansen CF, Johansen MB, Langeberg WJ, et al. Incidence of acute kidney injury in cancer patients: a Danish population-based cohort study. *European journal of internal medicine*. Elsevier; 2011;22(4): 399–406.
- Kitchlu A, McArthur E, Amir E, et al. Acute kidney injury in patients receiving systemic treatment for cancer: a population-based cohort study. *JNCI: Journal of the National Cancer Institute*. Oxford University Press; 2019;111(7): 727–736.

9. Lameire N, Vanholder R, Van Biesen W, et al. Acute kidney injury in critically ill cancer patients: an update. *Critical care*. BioMed Central; 2016;20(1): 1–12.
10. Lahoti A, Kantarjian H, Salahudeen AK, et al. Predictors and outcome of acute kidney injury in patients with acute myelogenous leukemia or high-risk myelodysplastic syndrome. *Cancer*. Wiley Online Library; 2010;116(17): 4063–4068.
11. Rosolem MM, Raballo LSCE, Lisboa T, et al. Critically ill patients with cancer and sepsis: clinical course and prognostic factors. *Journal of critical care*. Elsevier; 2012;27(3): 301–307.
12. Perazella MA. Renal vulnerability to drug toxicity. *Clinical Journal of the American Society of Nephrology*. Am Soc Nephrol; 2009;4(7): 1275–1283.
13. Lahoti A, Nates JL, Wakefield CD, et al. Costs and outcomes of acute kidney injury in critically ill patients with cancer. *The journal of supportive oncology*. Elsevier; 2011;9(4): 149–155.
14. Kogon A, Hingorani S. Acute kidney injury in hematopoietic cell transplantation. *Seminars in nephrology*. Elsevier; 2010. p. 615–626.
15. Berk L, Rana S. Hypovolemia and dehydration in the oncology patient. *The journal of supportive oncology*. 2006;4(9): 447–454.
16. Rosner MH, Jhaveri KD, McMahon BA, et al. Onconeurology: The intersections between the kidney and cancer. *CA: A Cancer Journal for Clinicians*. 2021;71(1): 47–77. doi:10.3322/caac.21636
17. Rosner MH, Perazella MA. Acute kidney injury in the patient with cancer. *Kidney Research and Clinical Practice*. 2019;38(3): 295–308. doi:10.23876/j.krcp.19.042
18. Humphreys BD, Soiffer RJ, Magee CC. Renal failure associated with cancer and its treatment: an update. *Journal of the American Society of Nephrology*. Am Soc Nephrol; 2005;16(1): 151–161.
19. Hutchison CA, Batuman V, Behrens J, et al. The pathogenesis and diagnosis of acute kidney injury in multiple myeloma. *Nature Reviews Nephrology*. Nature Publishing Group; 2012;8(1): 43–51.
20. Darmon M, Vincent F, Canet E, et al. Acute kidney injury in critically ill patients with haematological malignancies: results of a multicentre cohort study from the Groupe de Recherche en Réanimation Respiratoire en Onco-Hématologie. *Nephrology Dialysis Transplantation*. Oxford University Press; 2015;30(12): 2006–2013.
21. Khalil MAM, Latif H, Rehman A, et al. Acute kidney injury in lymphoma: a single centre experience. *International journal of nephrology*. Hindawi; 2014;2014.
22. Lommatsch SE, Bellizzi AM, Cathro HP, et al. Acute renal failure caused by renal infiltration by hematolymphoid malignancy. *Annals of diagnostic pathology*. Elsevier; 2006;10(4): 230–234.
23. Mallouk A, Pham P-TT, Pham P-CT. Concurrent FSGS and Hodgkin's lymphoma: case report and literature review on the link between nephrotic glomerulopathies and hematological malignancies. *Clinical and experimental nephrology*. Springer; 2006;10(4): 284–289.
24. Lai K-W, Wei C-L, Tan L-K, et al. Overexpression of interleukin-13 induces minimal-change-like nephropathy in rats. *Journal of the American Society of Nephrology*. Am Soc Nephrol; 2007;18(5): 1476–1485.

25. Au WY, Chan KW, Lui SL, et al. Focal segmental glomerulosclerosis and mesangial sclerosis associated with myeloproliferative disorders. *American journal of kidney diseases*. Elsevier; 1999;34(5): 889–893.
26. Eleutherakis-Papaiakovou V, Bamias A, Gika D, et al. Renal failure in multiple myeloma: incidence, correlations, and prognostic significance. *Leukemia & lymphoma*. Taylor & Francis; 2007;48(2): 337–341.
27. Finkel KW, Cohen EP, Shirali A, et al. Paraprotein-related kidney disease: evaluation and treatment of myeloma cast nephropathy. *Clinical Journal of the American Society of Nephrology*. Am Soc Nephrol; 2016;11(12): 2273–2279.
28. Berggard I, Peterson PA. Polymeric forms of free normal κ and λ chains of human immunoglobulin. *Journal of Biological Chemistry*. Elsevier; 1969;244(16): 4299–4307.
29. Mead GP, Carr-Smith HD, Drayson MT, et al. Serum free light chains for monitoring multiple myeloma. *British journal of haematology*. Wiley Online Library; 2004;126(3): 348–354.
30. Yadav P, Cockwell P, Cook M, et al. Serum free light chain levels and renal function at diagnosis in patients with multiple myeloma. *BMC nephrology*. BioMed Central; 2018;19(1): 1–8.
31. Hutchison CA, Basnayake K, Cockwell P. Serum free light chain assessment in monoclonal gammopathy and kidney disease. *Nature Reviews Nephrology*. Nature Publishing Group; 2009;5(11): 621–628.
32. Dimopoulos MA, Kastritis E, Terpos E, et al. International Myeloma Working Group recommendations for the diagnosis and management of myeloma-related renal impairment. *Journal of Clinical Oncology*. 2016;34(13): 1544–1557.
33. Nasr SH, Valeri AM, Sethi S, et al. Clinicopathologic correlations in multiple myeloma: a case series of 190 patients with kidney biopsies. *American Journal of Kidney Diseases*. Elsevier; 2012;59(6): 786–794.
34. Nowrouzian MR, Brandhorst D, Sammet C, et al. Serum free light chain analysis and urine immunofixation electrophoresis in patients with multiple myeloma. *Clinical cancer research*. AACR; 2005;11(24): 8706–8714.
35. Leung N, Behrens J. Current approach to diagnosis and management of acute renal failure in myeloma patients. *Advances in chronic kidney disease*. Elsevier; 2012;19(5): 297–302.
36. Dimopoulos MA, Roussou M, Gavriatopoulou M, et al. Bortezomib-based triplets are associated with a high probability of dialysis independence and rapid renal recovery in newly diagnosed myeloma patients with severe renal failure or those requiring dialysis. *American journal of hematology*. Wiley Online Library; 2016;91(5): 499–502.
37. Hutchison CA, Cockwell P, Stringer S, et al. Early reduction of serum-free light chains associates with renal recovery in myeloma kidney. *Journal of the American Society of Nephrology*. Am Soc Nephrol; 2011;22(6): 1129–1136.
38. Ludwig H, Adam Z, Hajek R, et al. Light chain-induced acute renal failure can be reversed by bortezomib-doxorubicin-dexamethasone in multiple myeloma: Results of a phase II study. *Journal of clinical oncology*. American Society of Clinical Oncology; 2010;28(30): 4635–4641.

39. Dimopoulos MA, Roussou M, Gkotzamanidou M, et al. The role of novel agents on the reversibility of renal impairment in newly diagnosed symptomatic patients with multiple myeloma. *Leukemia*. Nature Publishing Group; 2013;27(2): 423–429.
40. Chanan-Khan AA, Kaufman JL, Mehta J, et al. Activity and safety of bortezomib in multiple myeloma patients with advanced renal failure: a multicenter retrospective study. *Blood*. American Society of Hematology; 2007;109(6): 2604–2606.
41. Neri P, Bahlis NJ, Paba-Prada C, et al. Treatment of relapsed/refractory multiple myeloma. *Plasma Cell Dyscrasias*. Springer; 2016; 169–194.
42. Hoy SM. Carfilzomib triple combination therapy: A review in relapsed multiple myeloma. *Targeted oncology*. Springer; 2016;11(2): 255–262.
43. Glavey S V, Gertz MA, Dispenzieri A, et al. Long-term outcome of patients with mutiple myeloma-related advanced renal failure following auto-SCT. *Bone marrow transplantation*. Nature Publishing Group; 2013;48(12): 1543–1547.
44. Burnette BL, Leung N, Rajkumar SV. Renal improvement in myeloma with bortezomib plus plasma exchange. *The New England journal of medicine*. 2011;364(24): 2365–2366.
45. Bridoux F, Carron P-L, Pegourie B, et al. Effect of high-cutoff hemodialysis vs conventional hemodialysis on hemodialysis independence among patients with myeloma cast nephropathy: a randomized clinical trial. *Jama*. American Medical Association; 2017;318(21): 2099–2110.
46. Hutchison CA, Cockwell P, Moroz V, et al. High cutoff versus high-flux haemodialysis for myeloma cast nephropathy in patients receiving bortezomib-based chemotherapy (EuLITE): a phase 2 randomised controlled trial. *The Lancet Haematology*. Elsevier; 2019;6(4): e217–e228.
47. Howard SC, Pui C-H, Ribeiro RC. Tumor lysis syndrome. *Renal Disease in Cancer Patients*. Elsevier; 2014; 39–64.
48. Mirrakhimov AE, Voore P, Khan M, et al. Tumor lysis syndrome: a clinical review. *World Journal of Critical Care Medicine*. Baishideng Publishing Group Inc; 2015;4(2): 130.
49. Cairo MS, Coiffier B, Reiter A, et al. Recommendations for the evaluation of risk and prophylaxis of tumour lysis syndrome (TLS) in adults and children with malignant diseases: an expert TLS panel consensus. *British journal of haematology*. Wiley Online Library; 2010;149(4): 578–586.
50. Criscuolo M, Fianchi L, Dragonetti G, et al. Tumor lysis syndrome: review of pathogenesis, risk factors and management of a medical emergency. *Expert review of hematology*. Taylor & Francis; 2016;9(2): 197–208.
51. Garimella PS, Balakrishnan P, Ammakanavar NR, et al. Impact of dialysis requirement on outcomes in tumor lysis syndrome. *Nephrology*. Wiley Online Library; 2017;22(1): 85–88.
52. Wilson FP, Berns JS. Tumor lysis syndrome: new challenges and recent advances. *Advances in chronic kidney disease*. Elsevier; 2014;21(1): 18–26.
53. Cairo MS, Bishop M. Tumour lysis syndrome: new therapeutic strategies and classification. *British journal of haematology*. Wiley Online Library; 2004;127(1): 3–11.

54. Wilson FP, Berns JS. Onco-nephrology: tumor lysis syndrome. *Clinical Journal of the American Society of Nephrology*. Am Soc Nephrol; 2012;7(10): 1730–1739.
55. Shimada M, Johnson RJ, May Jr WS, et al. A novel role for uric acid in acute kidney injury associated with tumour lysis syndrome. Oxford University Press; 2009.
56. Boles J, Mialon P, Garre M, et al. Acute renal failure caused by extreme hyperphosphatemia after chemotherapy of an acute lymphoblastic leukemias. *Cancer*. Wiley Online Library; 1984;53(11): 2425–2429.
57. Bellos I, Kontzoglou K, Psyrra A, et al. Febuxostat administration for the prevention of tumour lysis syndrome: A meta-analysis. *Journal of clinical pharmacy and therapeutics*. Wiley Online Library; 2019;44(4): 525–533.
58. Alakel N, Middeke JM, Schetelig J, et al. Prevention and treatment of tumor lysis syndrome, and the efficacy and role of rasburicase. *OncoTargets and therapy*. Dove Press; 2017;10: 597.
59. Cortes J, Moore JO, Maziarz RT, et al. Control of plasma uric acid in adults at risk for tumor Lysis syndrome: efficacy and safety of rasburicase alone and rasburicase followed by allopurinol compared with allopurinol alone—results of a multicenter phase III study. *Journal of clinical oncology*. American Society of Clinical Oncology; 2010;28(27): 4207.
60. Khan M, Paul S, Farooq S, et al. Rasburicase-induced methemoglobinemia in a patient with glucose-6-phosphate dehydrogenase deficiency. *Current drug safety*. Bentham Science Publishers; 2017;12(1): 13–18.
61. Sherwood GB, Paschal RD, Adamski J. Rasburicase-induced methemoglobinemia: case report, literature review, and proposed treatment algorithm. *Clinical case reports*. Wiley-Blackwell; 2016;4(4): 315.
62. Rosner MH, Dalkin AC. Onco-nephrology: the pathophysiology and treatment of malignancy-associated hypercalcemia. *Clinical Journal of the American Society of Nephrology*. Am Soc Nephrol; 2012;7(10): 1722–1729.
63. Mazzone PJ, Arroliga AC. Endocrine paraneoplastic syndromes in lung cancer. *Current opinion in pulmonary medicine*. LWW; 2003;9(4): 313–320.
64. Donovan PJ, Achong N, Griffin K, et al. PTHrP-mediated hypercalcemia: causes and survival in 138 patients. *The Journal of Clinical Endocrinology & Metabolism*. Oxford University Press; 2015;100(5): 2024–2029.
65. Toka HR, Al-Romaih K, Koshy JM, et al. Deficiency of the calcium-sensing receptor in the kidney causes parathyroid hormone-independent hypocalciuria. *Journal of the American Society of Nephrology*. Am Soc Nephrol; 2012;23(11): 1879–1890.
66. Rosner MH, Perazella MA. Acute kidney injury in patients with cancer. *New England Journal of Medicine*. Mass Medical Soc; 2017;376(18): 1770–1781.
67. LeGrand SB, Leskuski D, Zama I. Narrative review: furosemide for hypercalcemia: an unproven yet common practice. *Annals of internal medicine*. American College of Physicians; 2008;149(4): 259–263.
68. BINSTOCK ML, MUNDY GR. Effect of calcitonin and glucocorticoids in combination on the hypercalcemia of malignancy. *Annals of Internal Medicine*. American College of Physicians; 1980;93(2): 269–272.

69. Eastell R, Christiansen C, Grauer A, et al. Effects of denosumab on bone turnover markers in postmenopausal osteoporosis. *Journal of Bone and Mineral Research*. Wiley Online Library; 2011;26(3): 530–537.
70. Cardella CJ, Birkin BL, Rapoport A. Role of dialysis in the treatment of severe hypercalcemia: report of two cases successfully treated with hemodialysis and review of the literature. *Clinical nephrology*. 1979;12(6): 285–290.
71. Lahoti A, Humphreys BD. Chapter 3 : AKI Associated With Malignancies. *Onco-Nephrology Curriculum*. 2016; 1–8.
72. Moake JL. Thrombotic microangiopathies. *New England Journal of Medicine*. Mass Medical Soc; 2002;347(8): 589–600.
73. Kwaan HC, Gordon LI. Thrombotic microangiopathy in the cancer patient. *Acta haematologica*. Karger Publishers; 2001;106(1–2): 52–56.
74. Weitz IC. Thrombotic microangiopathy in cancer. *Seminars in thrombosis and hemostasis*. Thieme Medical Publishers; 2019. p. 348–353.
75. Renaghan AD, Jaimes EA, Malyszko J, et al. Acute kidney injury and CKD associated with hematopoietic stem cell transplantation. *Clinical Journal of the American Society of Nephrology*. Am Soc Nephrol; 2020;15(2): 289–297.
76. Ishida Y, Yamashita K, Sasaki H, et al. Activation of complement system in adult T-cell leukemia (ATL) occurs mainly through lectin pathway: a serum proteomic approach using mass spectrometry. *Cancer letters*. Elsevier; 2008;271(1): 167–177.
77. Krisinger MJ, Goebeler V, Lu Z, et al. Thrombin generates previously unidentified C5 products that support the terminal complement activation pathway. *Blood, The Journal of the American Society of Hematology*. American Society of Hematology Washington, DC; 2012;120(8): 1717–1725.
78. Malina M, Roumenina LT, Seeman T, et al. Genetics of hemolytic uremic syndromes. *La Presse Médicale*. Elsevier; 2012;41(3): e105–e114.
79. Walter RB, Joerger M, Pestalozzi BC. Gemcitabine-associated hemolytic-uremic syndrome. *American Journal of Kidney Diseases*. Elsevier; 2002;40(4): e16–1.
80. Al Ustwani O, Lohr J, Dy G, et al. Eculizumab therapy for gemcitabine induced hemolytic uremic syndrome: case series and concise review. *Journal of gastrointestinal oncology*. AME Publications; 2014;5(1): E30.
81. Licciardello JTW, Moake JL, Rudy CK, et al. Elevated plasma von Willebrand factor levels and arterial occlusive complications associated with cisplatin-based chemotherapy. *Oncology*. Karger Publishers; 1985;42(5): 296–300.
82. Gardner G, Mesler D, Gitelman HJ. Hemolytic Uremic Syndrome Following Cisplatin, Bleomycin, and Vincristine Chemotherapy. *Renal failure*. Taylor & Francis; 1989;11(2–3): 133–137.
83. Walker RW, Rosenblum MK, Kempin SJ, et al. Carboplatin-associated thrombotic microangiopathic hemolytic anemia. *Cancer*. Wiley Online Library; 1989;64(5): 1017–1020.
84. Izzedine H, Escudier B, Lhomme C, et al. Kidney diseases associated with anti-vascular endothelial growth factor (VEGF): an 8-year observational study at a single center. *Medicine*. Wolters Kluwer Health; 2014;93(24).

85. Zeisbrich M, Becker N, Benner A, et al. Transplant-associated thrombotic microangiopathy is an endothelial complication associated with refractoriness of acute GvHD. *Bone marrow transplantation*. Nature Publishing Group; 2017;52(10): 1399–1405.
86. Kim SS, Patel M, Yum K, et al. Hematopoietic stem cell transplant-associated thrombotic microangiopathy: review of pharmacologic treatment options. *Transfusion*. Wiley Online Library; 2015;55(2): 452–458.
87. Brocklebank V, Wood KM, Kavanagh D. Thrombotic microangiopathy and the kidney. *Clinical Journal of the American Society of Nephrology*. Am Soc Nephrol; 2018;13(2): 300–317.
88. Lefaucheur C, Stengel B, Nochy D, et al. Membranous nephropathy and cancer: epidemiologic evidence and determinants of high-risk cancer association. *Kidney international*. Elsevier; 2006;70(8): 1510–1517.
89. Pai P, Bone JM, McDicken I, et al. Solid tumour and glomerulopathy. *QJM: An International Journal of Medicine*. Oxford University Press; 1996;89(5): 361–368.
90. Bacchetta J, Juillard L, Cochat P, et al. Paraneoplastic glomerular diseases and malignancies. *Critical reviews in oncology/hematology*. Elsevier; 2009;70(1): 39–58.
91. Mustonen J, Pasternack A. Associated diseases in IgA nephropathy. *IgA nephropathy*. Springer; 1987. p. 47–65.
92. Baldeo C, Ali R, Hritani A, et al. ANCA-negative pauci-immune crescentic glomerulonephritis linked with non-small cell carcinoma of the lung. *Case reports in nephrology and dialysis*. Karger Publishers; 2015;5(2): 168–172.
93. Lundberg WB, Cadman ED, Finch SC, et al. Renal failure secondary to leukemic infiltration of the kidneys. *The American journal of medicine*. Elsevier; 1977;62(4): 636–642.
94. Schmid M, Krishna N, Ravi P, et al. Trends of acute kidney injury after radical or partial nephrectomy for renal cell carcinoma. *Urologic Oncology: Seminars and Original Investigations*. Elsevier; 2016. p. 293-e1.
95. Małyszko J, Kozłowska K, Kozłowski L, et al. Nephrotoxicity of anticancer treatment. *Nephrology Dialysis Transplantation*. 2017;32(6): 924–936. doi:10.1093/ndt/gfw338
96. Bressler RB, Huston DP. Water intoxication following moderate-dose intravenous cyclophosphamide. *Archives of internal medicine*. American Medical Association; 1985;145(3): 548–549.
97. Santos MLC, Brito BB de, Silva FAF da, et al. Nephrotoxicity in cancer treatment: An overview. *World Journal of Clinical Oncology*. 2020;11(4): 190–204. doi:10.5306/wjco.v11.i4.190
98. Lim SR, Hyun S, Lee SG, et al. Potential urinary biomarkers of nephrotoxicity in cyclophosphamide-treated rats investigated by NMR-based metabolic profiling. *Journal of biochemical and molecular toxicology*. Wiley Online Library; 2017;31(3): e21871.
99. Greenbaum-Lefkoe B, Rosenstock JG, Belasco JB, et al. Syndrome of inappropriate antidiuretic hormone secretion. A complication of high-dose intravenous melphalan. *Cancer*. Wiley Online Library; 1985;55(1): 44–46.

100. Graham ML, Janecek JL, Kittredge JA, et al. The streptozotocin-induced diabetic nude mouse model: differences between animals from different sources. *Comparative medicine*. American Association for Laboratory Animal Science; 2011;61(4): 356–360.
101. Crona DJ, Faso A, Nishijima TF, et al. A systematic review of strategies to prevent cisplatin-induced nephrotoxicity. *The oncologist*. Wiley-Blackwell; 2017;22(5): 609.
102. Dobyan DC, Levi J, Jacobs C, et al. Mechanism of cis-platinum nephrotoxicity: II. Morphologic observations. *Journal of Pharmacology and Experimental Therapeutics*. ASPET; 1980;213(3): 551–556.
103. Kintzel PE, Dorr RT. Anticancer drug renal toxicity and elimination: dosing guidelines for altered renal function. *Cancer treatment reviews*. Elsevier; 1995;21(1): 33–64.
104. Labaye J, Sarret D, Duvic C, et al. Renal toxicity of oxaliplatin. *Nephrology Dialysis Transplantation*. Oxford University Press; 2005;20(6): 1275–1276.
105. Takimoto CH, Remick SC, Sharma S, et al. Dose-escalating and pharmacological study of oxaliplatin in adult cancer patients with impaired renal function: a National Cancer Institute Organ Dysfunction Working Group Study. *Journal of clinical oncology*. American Society of Clinical Oncology; 2003;21(14): 2664–2672.
106. Widemann BC, Adamson PC. Understanding and managing methotrexate nephrotoxicity. *The oncologist*. Wiley Online Library; 2006;11(6): 694–703.
107. Mita AC, Sweeney CJ, Baker SD, et al. Phase I and pharmacokinetic study of pemetrexed administered every 3 weeks to advanced cancer patients with normal and impaired renal function. *Journal of clinical oncology*. American Society of Clinical Oncology; 2006;24(4): 552–562.
108. Rabah SO. Acute Taxol nephrotoxicity: Histological and ultrastructural studies of mice kidney parenchyma. *Saudi journal of biological sciences*. Elsevier; 2010;17(2): 105–114.
109. Krens SD, Lassche G, Jansman FGA, et al. Dose recommendations for anticancer drugs in patients with renal or hepatic impairment. *The Lancet Oncology*. Elsevier; 2019;20(4): e200–e207.
110. Cutting HO. Inappropriate secretion of antidiuretic hormone secondary to vincristine therapy. *The American journal of medicine*. Elsevier; 1971;51(2): 269–271.
111. Kanchi H, Webb NJA, Eden OB. Hemolytic uremic syndrome secondary to the treatment of acute lymphoblastic leukemia. *Journal of pediatric hematology/oncology*. LWW; 2000;22(5): 483–484.
112. Shavit L, Lifschitz MD, Gabizon A, et al. Pegylated liposomal doxorubicin and renal thrombotic microangiopathy: an under-recognized complication of prolonged treatment for ovarian cancer. *Kidney international*. Elsevier; 2014;85(1): 213.
113. Giroux L, Bettez P, Giroux L. Mitomycin-C nephrotoxicity: a clinico-pathologic study of 17 cases. *American Journal of Kidney Diseases*. Elsevier; 1985;6(1): 28–39.
114. Harris E, Behrens J, Samson D, et al. Use of thalidomide in patients with myeloma and renal failure may be associated with unexplained hyperkalaemia. *British journal of haematology*. Wiley Online Library; 2003;122(1): 160–161.

115. Launay-Vacher V, Deray G. Hypertension and proteinuria: a class-effect of antian- giogenic therapies. *Anti-cancer drugs*. LWW; 2009;20(1): 81–82.
116. Van Cutsem E, Tabernero J, Lakomy R, et al. Addition of afiblercept to fluorouracil, leucovorin, and irinotecan improves survival in a phase III randomized trial in pa- tients with metastatic colorectal cancer previously treated with an oxaliplatin-based regimen. *J Clin Oncol*. 2012;30(28): 3499–3506.
117. Tomita Y, Uemura H, Fujimoto H, et al. Key predictive factors of axitinib (AG- 013736)-induced proteinuria and efficacy: a phase II study in Japanese patients with cytokine-refractory metastatic renal cell carcinoma. *European journal of cancer*. El- sevier; 2011;47(17): 2592–2602.
118. Launay-Vacher V, Aapro M, De Castro Jr G, et al. Renal effects of molecular tar- geted therapies in oncology: a review by the Cancer and the Kidney International Network (C-KIN). *Annals of Oncology*. Elsevier; 2015;26(8): 1677–1684.
119. Patel T V, Morgan JA, Demetri GD, et al. A preeclampsia-like syndrome charac- terized by reversible hypertension and proteinuria induced by the multitargeted kinase inhibitors sunitinib and sorafenib. *Journal of the National Cancer Institute*. Oxford University Press; 2008;100(4): 282–284.
120. Maruyama K, Chinda J, Kuroshima T, et al. Minimal change nephrotic syndrome associated with gefitinib and a successful switch to erlotinib. *Internal Medicine*. The Japanese Society of Internal Medicine; 2015;54(7): 823–826.
121. Jhaveri KD, Sakhya V, Wanchoo R, et al. Renal effects of novel anticancer targeted therapies: a review of the Food and Drug Administration Adverse Event Reporting System. *Kidney international*. Elsevier; 2016;90(3): 706–707.
122. Groenestege WMT, Thébault S, van der Wijst J, et al. Impaired basolateral sorting of pro-EGF causes isolated recessive renal hypomagnesemia. *The Journal of clinical investigation*. Am Soc Clin Investig; 2007;117(8): 2260–2267.
123. Tejpar S, Piessevaux H, Claes K, et al. Magnesium wasting associated with epider- mal-growth-factor receptor-targeting antibodies in colorectal cancer: a prospective study. *The lancet oncology*. Elsevier; 2007;8(5): 387–394.
124. Schrag D, Chung KY, Flombaum C, et al. Cetuximab therapy and symptomatic hy- pomagnesemia. *Journal of the National Cancer Institute*. Oxford University Press; 2005;97(16): 1221–1224.
125. Jhaveri KD, Sakhya V, Fishbane S. Nephrotoxicity of the BRAF inhibitors vemur- aafenib and dabrafenib. *JAMA oncology*. American Medical Association; 2015;1(8): 1133–1134.
126. Wanchoo R, Jhaveri KD, Deray G, et al. Renal effects of BRAF inhibitors: a sys- tematic review by the Cancer and the Kidney International Network. *Clinical kidney journal*. Oxford University Press; 2016;9(2): 245–251.
127. Gastaud L, Ambrosetti D, Otto J, et al. Acute kidney injury following crizotinib ad- ministration for non-small-cell lung carcinoma. *Lung Cancer*. Elsevier; 2013;82(2): 362–364.
128. Cortes JE, Gambacorti-Passerini C, Kim D-W, et al. Effects of bosutinib treatment on renal function in patients with Philadelphia chromosome-positive leukemias. *Clinical Lymphoma Myeloma and Leukemia*. Elsevier; 2017;17(10): 684–695.

129. Pou M, Saval N, Vera M, et al. Acute renal failure secondary to imatinib mesylate treatment in chronic myeloid leukemia. *Leukemia & lymphoma*. Taylor & Francis; 2003;44(7): 1239–1241.
130. Ozkurt S, Temiz G, Acikalin MF, et al. Acute renal failure under dasatinib therapy. *Renal failure*. Taylor & Francis; 2010;32(1): 147–149.
131. Yui JC, Dispenzieri A, Leung N. Ixazomib-induced thrombotic microangiopathy. *American journal of hematology*. Wiley Online Library; 2017;92(4): E53–E55.
132. Hobeika L, Self SE, Velez JCQ. Renal thrombotic microangiopathy and podocytopathy associated with the use of carfilzomib in a patient with multiple myeloma. *BMC nephrology*. Springer; 2014;15(1): 1–6.
133. Hájek R, Masszi T, Petrucci MT, et al. A randomized phase III study of carfilzomib vs low-dose corticosteroids with optional cyclophosphamide in relapsed and refractory multiple myeloma (FOCUS). *Leukemia*. Nature Publishing Group; 2017;31(1): 107–114.
134. Cheungpasitporn W, Leung N, Rajkumar SV, et al. Bortezomib-induced acute interstitial nephritis. *Nephrology Dialysis Transplantation*. Oxford University Press; 2015;30(7): 1225–1229.
135. Izzedine H, Escudier B, Rouvier P, et al. Acute tubular necrosis associated with mTOR inhibitor therapy: a real entity biopsy-proven. *Annals of oncology*. Elsevier; 2013;24(9): 2421–2425.
136. Izzedine H, Boostandoot E, Spano JP, et al. Temsirolimus-induced glomerulopathy. *Oncology*. Karger Publishers; 2009;76(3): 170–172.
137. Selby P, Kohn J, Raymond J, et al. Nephrotic syndrome during treatment with interferon. *British medical journal (Clinical research ed.)*. BMJ Publishing Group; 1985;290(6476): 1180.
138. Zuber J, Martinez F, Droz D, et al. Alpha-interferon-associated thrombotic microangiopathy: a clinicopathologic study of 8 patients and review of the literature. *Medicine*. LWW; 2002;81(4): 321–331.
139. Markowitz GS, Nasr SH, Stokes MB, et al. Treatment with IFN- α , - β , or - γ is associated with collapsing focal segmental glomerulosclerosis. *Clinical Journal of the American Society of Nephrology*. Am Soc Nephrol; 2010;5(4): 607–615.
140. Guleria AS, Yang JC, Topalian SL, et al. Renal dysfunction associated with the administration of high-dose interleukin-2 in 199 consecutive patients with metastatic melanoma or renal carcinoma. *Journal of clinical oncology*. 1994;12(12): 2714–2722.
141. Hingorani S. Renal complications of hematopoietic-cell transplantation. *New England Journal of Medicine*. Mass Medical Soc; 2016;374(23): 2256–2267.
142. Parikh CR, Yarlagadda SG, Storer B, et al. Impact of acute kidney injury on long-term mortality after nonmyeloablative hematopoietic cell transplantation. *Biology of Blood and Marrow Transplantation*. Elsevier; 2008;14(3): 309–315.
143. Parikh CR, Coca SG. Acute renal failure in hematopoietic cell transplantation. *Kidney international*. Elsevier; 2006;69(3): 430–435.
144. Keating GM. Defibrotide: a review of its use in severe hepatic veno-occlusive disease following haematopoietic stem cell transplantation. *Clinical drug investigation*. Springer; 2014;34(12): 895–904.

145. Domschke C, Schuetz F. Side effects of bone-targeted therapies in advanced breast cancer. *Breast Care*. Karger Publishers; 2014;9(5): 332–336.
146. Edwards BJ, Usmani S, Raisch DW, et al. Acute kidney injury and bisphosphonate use in cancer: a report from the research on adverse drug events and reports (RADAR) project. *Journal of oncology practice*. American Society of Clinical Oncology Alexandria, VA; 2013;9(2): 101–106.
147. Markowitz GS, Fine PL, Stack JI, et al. Toxic acute tubular necrosis following treatment with zoledronate (Zometa). *Kidney international*. Elsevier; 2003;64(1): 281–289.
148. Markowitz GS, Appel GB, Fine PL, et al. Collapsing focal segmental glomerulosclerosis following treatment with high-dose pamidronate. *Journal of the American Society of Nephrology*. Am Soc Nephrol; 2001;12(6): 1164–1172.
149. Bodmer M, Amico P, Mihatsch MJ, et al. Focal segmental glomerulosclerosis associated with long-term treatment with zoledronate in a myeloma patient. *Nephrology Dialysis Transplantation*. Oxford University Press; 2007;22(8): 2366–2370.
150. Anderson K, Ismaila N, Flynn PJ, et al. Role of bone-modifying agents in multiple myeloma: American Society of Clinical Oncology clinical practice guideline update. American Society of Clinical Oncology; 2018.
151. Lipton A, Fizazi K, Stopeck AT, et al. Superiority of denosumab to zoledronic acid for prevention of skeletal-related events: a combined analysis of 3 pivotal, randomised, phase 3 trials. *European Journal of Cancer*. Elsevier; 2012;48(16): 3082–3092.
152. Body J-J, Bone HG, De Boer RH, et al. Hypocalcaemia in patients with metastatic bone disease treated with denosumab. *European Journal of Cancer*. Elsevier; 2015;51(13): 1812–1821.
153. Lameire NH, Flombaum CD, Moreau D, et al. Acute renal failure in cancer patients. *Annals of Medicine*. 2005;37(1): 13–25. doi:10.1080/07853890510007205